

A Contextual Framework for Computerized Information Systems

Agneta Olerup

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A CONTEXTUAL FRAMEWORK FOR COMPUTERIZED INFORMATION SYSTEMS

An exploratory study of computerized information systems in nine manufacturing organizations with regard to technological and environmental factors.

by

Agneta Olerup

civilekonom, Ld

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Abstract Research within contingency theory recognizes and postulates the relevance of contextual factors to the design of organizations. Thus organizations are dependent on the environments in which they operate and on the technologies they utilize. Organizations therefore need to process information about their environments and technologies. Information systems, including computerized information systems, play an important part in organizations and the relationships between computerized information systems and organizational context need to be considered. In this study it is hypothesized that differences in the characteristics of computerized information systems in different organizations can to some extent be explained by differences in these organizational contexts. A major distinction is made between content-oriented and generic classification models of computerized information systems. A model for describing generic characteristics of computerized information systems is suggested. This model proposes that the characteristics of a computerized information system can be classified on the one hand in terms of time-orientation or complexity, and on the other hand in terms of data-base, reports or processing. In the empirical part of the study the model proposed is illustrated. Data were collected using semi-structured interviews on technology, environment and computerized information systems for production control in nine large manufacturing organizations. The results are formulated as detailed hypotheses, which are consistent with the original, general hypothesis.		
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Signature Agneta Ölerup

Date 1982-04-26

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Computerized Information System**

HANDELSHØJSKOLEN I KØBENHAVN
SKRIFTRÆKKE O

Skrifter fra Institut for
organisation og arbejdssociologi

Under redaktion af professor Torben Agersnap

12

Agneta Olerup

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Computerized Information Systems

ERHVERVSØKONOMISK FORLAG S/I

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Research takes time, and considerable time generally elapses before the final report of the research is completed. This report is no exception to this rule, as the study was planned and the empirical data collected in 1977.

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1. INTRODUCTION

The relevance of contextual factors to the design of organizations has long been recognized. For example, it is recognized that organizations are affected by technology, by other organizations and by general social, demographic and economic conditions.

Similarly there is a growing awareness of the important part played by information systems in organizations, a part which has been further promoted by the development of information technology in general and computers and word processing equipment in particular. Several studies have provided significant insights into the impact of computers and computerized information systems on organizations and major research projects have been devoted to developing methods for computer system design. However, in this work virtually no explicit attention has been devoted to those contextual factors that affect computerized information systems.

The study reported here represents an attempt to develop insights and tools relevant to establishing the relationship between the organizational context and computerized information systems.

As introduction to the study, a frame of reference is presented in which it is argued that computerized information systems constitute a subsystem of the structure of an organization.

Next, the objectives, delimitations and approach of the present study are presented. Further, a fundamental hypothesis is discussed. Finally, an outline of the report is presented.

1.1 A frame of reference

An organization operates in an environment, receiving inputs from that environment and exporting outputs back. Its continued existence requires an organization to maintain favourable exchange relationships with other groups and organizations in the environment.

The inputs received by an organization are transformed into outputs. *Technology* is the means or processes used in converting an input into output in the organization. An organization may utilize several technologies for transforming different types of input.

In order to acquire inputs, convert them and export the outputs, an organization engages in many activities. These activities need to be coordinated and controlled. Information systems and information technology are closely interwoven into the processes of control and coordination within an organization.

Information technology is the means used in transforming information. It assists in collecting, storing, processing and distributing information needed for coordination and control. The importance of information technology derives from the possibilities for enhancing the information processing capabilities of individuals as decision-makers. Computers, models of operations research and methods for computer system design are some important kinds of information technology. Hence, *information technology* can be regarded as constituting an important *subset of the technology of an organization*.

An information system includes activities for collecting, storing, processing and distributing information about an organization and its environment. Information is required to control behaviour and is a necessary prerequisite for any organization activity. The importance of information derives from the contribution it makes in support of decision-making concerning coordination and control of organizational activities. Hence, information systems and information are central to many processes within organizations since they serve to indicate the objectives of the organizations, as well as acceptable ways of achieving them. *Information systems* can thus be regarded as constituting an essential *subset of the structure of an organization*.

All information systems in an organization can, in principle, be classified according to their degree of formalization. *Formalization* refers to categories and rules for classifying and dealing with situations. An information system is formalized when it consists of pre-determined categories of information as well as predetermined rules for processing the information. Thus only a subset of the information systems in an organization are formalized. The use of computers, however, presumes that information and rules for processing are pre-defined or may be pre-defined. Hence computerized information systems are subsets of formalized information systems.

The concept of *formal* information system is often used in the sense of formalized information system as above but more often in the sense of a legitimized or officially sanctioned system. The uses of the terms formal and formalized are often confusing.

The concept of *formal information system* will be used to refer to the legitimacy or official sanctioning of an information system. *Formalized information systems* have previously been defined as consisting of pre-defined information categories and rules for processing information. Hence formal and formalized information systems are considered as distinct and separate concepts, referring to different dimensions.

In the present study only the concept formalized information systems will be used. Computerized information systems are a subset of the formalized information systems, and thus of the information systems of an organization. Further, information systems are a subset of the structure of an organization, and information technology is a subset of the technology of an organization.

There is a large body of research on the importance of contextual variables with regard to organizational structure. For example, it is recognized that organizational structure is contingent upon technological and upon environmental factors (including other organizations) social, demographic and economic conditions. Similarly it can be demonstrated that an organization's technology and its environment have important implications for the formalized and computerized information systems in an organization.

1.2 Objectives, delimitations and approach of the study

The findings of this study are directed towards two main interest groups. The first consists of those who are responsible for designing computerized information systems that are consonant with the organization and its context. Their efforts can benefit from an increased understanding of the implications of organizational context for computerized information systems. The second interest group comprises those researchers who study the relationships between organizations

and computerized information systems.

The major purpose of this study is to examine the relationship between computerized information systems and two contextual variables: technology and environment. This requires that characteristics of computerized information systems are identified. A secondary purpose is, therefore, to develop a model of the characteristics of computerized information system.

A broader purpose of this study is to contribute to the development of theories which integrate computerized information systems and computer system design with theories of organization. Theory is used in adherence to the dictionary definition "a formulation of apparent relationships or underlying principles of certain observed phenomena which has been verified to some degree" (Webster Unabridged 1978). Hence theory in this sense is not a statement about how things ought, ideally, to be, but rather an abstract model or language for organizing the complexities of organizations. Theory in this sense is derived from careful observation of how things seem to operate in the real world.

Some delimitations have already been introduced. First, this study is not concerned with information systems in general but only with the subset of computerized information systems. Further, the focus of the study is those computerized information systems related to activities for acquiring material, converting it and disposing of the products. Hence, computerized information systems for accounting, personnel etc are not considered.

Second, as will be discussed in later chapters, the computerized information systems studied are only examined in relation to two contextual variables: technology and environment. A third contextual variable, size, is not considered although the influence of size has been controlled for. Further the influence of production technology but not the influence of information technology on computerized information systems is considered.

A third delimitation concerns the level of study. Computerized information systems in organizations can be studied on an individual, group, or organizational level. In this study, an organizational level of study has been chosen.

The conceptual approach that is used in the study is a contingency approach. Contingency approaches are based on the notion of a fit between two entities: the form in question and its context. The form consists of those variables over which we have control and which we decide to shape: the context consists of those variables which put demands and constraints on the form. Fitness is a relation of mutual acceptability between form and context (Alexander 1970). In this study form refers to the characteristics of computerized information systems.

Continuing efforts have been devoted in the literature to developing and refining contingency approaches. These efforts have involved a number of fundamental criticisms. In addition, new concepts such as strategic choice (Child 1972) and environmental enactment (Weick 1979) have been introduced, and hence changes in contingency approaches implied, since the empirical data for the research reported was collected, in 1977.

A fourth delimitation, therefore, concerns the choice of contingency approach. A rather traditional approach has been used, in which the environment and the technology of an organization are seen to influence rather than be influenced by the computerized information system. This appears reasonable in the short run. Computerized information systems generally have short expected lifetimes and it is therefore unlikely that an organization chooses its environment and production technology on the basis of its information technology and computerized information systems. It seems more likely that information technology is chosen and computerized information systems are designed in order to match the existing environment and technology of an organization. In the long run, the relations between environment, technology and computerized information systems are more complex involving mutual interdependencies. The contingency approach implied by this longer time perspective requires data collection over

an extended period of time and a research design oriented towards longitudinal case studies. Such case studies were, however, beyond the scope of this study, as they required research-resources in excess of those available.

As already mentioned (section 1.1), this study is concerned only with formalized information systems and particularly computerized information systems. However, informal systems exist in addition to the formalized ones. Informal systems may, therefore be used to supplement deficiencies in the match between the contextual factors and the computerized information systems. Since informal systems may therefore make up for inadequacies in the formalized systems, this factor may explain the absence or lack of observed relationships between the contextual variables and computerized information system characteristics.

A fifth delimitation therefore concerns the fact that both formalized manual systems and informal systems have been excluded from the study. This delimitation is closely related to the previous one concerning the choice of a traditional contingency approach. This is perhaps unfortunate as there has been an extensive discussion during recent years on informal systems. At the time when the present study was conceived, this debate was just beginning and should it have been taken into account, the scope of the study would necessarily have been considerably enlarged. Specifically it would have been necessary to collect other types of data, which would have required intensive case-studies using unstructured, probing interviews, instead of case-studies based on semi-structured interviews.

The first three delimitations serve to restrict the focus of study, through the choice of computerized information systems, organizational context and an organizational level of study. The last two delimitations, on the other hand, imply a restriction of the factors which can be considered in explaining the influences on computerized information systems. Those factors not included in the study may, however, explain any observed discrepancies and variations from the expected pattern of results. It will have to be addressed in later studies which of the factors not considered are important in explaining the variations and lack of consistency in the results obtained in this study.

1.3 Fundamental hypothesis

Computerized information systems need to be considered in a wider framework and not only as having the purpose of producing certain types of information. It was previously argued that computerized information systems are a subset of the structure of an organization.

There are two main ideas behind research on organizational structure using contingency approaches: first, there is no one best way to organize: and second, any way of organizing is not equally effective (Galbraith 1973).

Similarly it seems reasonable to conclude that different organizations require different computerized information systems, having different characteristics.

Thus, the fundamental hypothesis in this study is that differences in the characteristics of computerized information systems can to some extent be explained by differences in organizational context. Further, the differences cannot be explained exclusively with reference to the nature of computer systems and computers.

1.4 An outline of the report

In the next four chapters (chapters 2-5) a framework for this study is developed and presented. This is based on surveys of literature. In chapter 2 models and methods for designing computerized information systems are discussed. In chapter 3 organizational structure and context is

discussed. Organizations are considered as systems for processing information, hence uncertainty and information are important concepts. Three contextual factors, size, environment and technology are identified, as well as environmental and technological variables. In chapter 4, the organizational relationships of computerized information systems are reviewed based on existing studies. Finally, in chapter 5, models of computerized information systems are reviewed and a model for describing computerized information systems with regard to contextual factors is proposed.

The framework and model of computerized information systems are illustrated by empirical data from nine manufacturing companies. In chapter 6 the design of the empirical study and the methods used are discussed.

In the next three chapters (chapter 7-9) and the appendix the empirical study is presented and analyzed. In chapter 7 groups of companies are formed, based on technological and environmental types. In chapter 8 patterns of computerized information systems are analyzed. The characteristics of the computerized information systems for each of the groups of companies are analyzed. Finally, chapter 9 provides a summary of the research results. The detailed data are presented in the appendix.

In a postscript (chapter 10), criticisms of contingency theory are reviewed, and their relevance is discussed as regards the research reported and the results obtained.

2. COMPUTERIZED INFORMATION SYSTEMS – ANALYSIS AND DESIGN

In the previous chapter it was argued that an information system is an integrated subset of organizational structure and that information technology is a subset of the technology of an organization. It was further argued that a computerized information system is a formalized one.

It was hypothesised that differences between computerized information systems can be explained to some extent by differences in organizational environment and technology. The characteristics of a computerized information system, and thus the goodness of fit between a computerized information system and the organizational context, is to a high degree determined by the process of designing computerized information systems - or computer system design for short. In order to improve the impact and performance of a computer system it is necessary to improve the process of computer system design. Hence the process of computer system design is analysed with particular regard to normative models and methods.

Currently the dominant approaches for computer system design are life cycle models. Several amendments and alternatives to these models have however been put forward recently. These include participative approaches, as well as experimental approaches, and finally contingency approaches.

2.1 The structure of design processes

It may often be convenient to imagine that a design process starts with the recognition of an opportunity or of a problem. Further choice opportunities are then seen to lead first to the generation of decision alternatives, then to an examination of their consequences, then to an evaluation of the consequences in terms of objectives, and finally to a decision.

This simple problem-solving model assumes a clear understanding of design or decision situations, that problems lead to solutions, it further postulates a simple sequence of steps. This is, however, often a poor description of what actually happens.

Instead of problems leading to solutions, solutions may be looking for problems. It has been suggested that one can view a choice opportunity as a garbage can into which various kinds of problems and solutions are dumped by participants as they are generated (Cohen et al 1972). In the garbage can model, a decision is an outcome or interpretation of four major streams of problems, solutions, participants and choice opportunities. These streams are seen as relatively independent within an organization.

Similarly, Mintzberg et al (1976) suggested that an organization usually begins with little understanding of the design or decision situation it faces or the route to its solutions. It is further suggested that the organization has only a vague idea of what that solution might be and how it will be evaluated when it is developed. The organization gropes through a recursive, discontinuous process involving many different steps, and influenced by a host of dynamic factors, over a considerable period of time; only in this way is a final choice made. Distinct phases and steps may be delineated in the process but a simple sequential relationship between them cannot be postulated.

The alternative approaches to design processes provide important insights. In spite of the fact that several theoretical and normative models do exist taking these into account, they have only been used to a very limited extent in practice. Accordingly these "alternative" models do not provide insight into normative procedures actually followed by system designers in the companies studied. The accepted normative model is still the simple problem-solving model with regard to computer system design.

2.2 Computer system design - methodology

The process of designing computerized information systems may be given all the characteristics of a problem-solving process or a decision-making process. It generally starts with the recognition of an opportunity or of a problem. The process gains momentum from the desire or the need to reduce the gap between the perceived and the desired state of things in the problem area it approaches. The purpose of the design process is to develop a computerized information system that will improve performance in the problem-area or the organization. The design-process may involve exploring, formulating and choosing among alternative forms of a computerized information system and evaluating the implemented computerized information system.

Designing computerized information systems is a complex process that is difficult to predict. It may also be an ill-structured process. Among the contributing factors are the large number of components and variables in any information system. Further, the technology is not well known, nor is it static. Third, the task has often a large scope involving many members of the organization. Each computerized information system may to some extent be unique as similar systems are seldom constructed under similar conditions.

Empirical descriptions of computer system design are important in gaining an understanding of what actually happens when designing a computerized information system. The process of computer system design may however be considered from a normative and prescriptive point of view as well. In order to improve computer design the normative models are important. Hence the analysis will be limited to those models.

Computer system design is a time, manpower and resource consuming process, hence the normative models are usually directed towards planning, controlling and coordinating the process of computer system design, which for these purposes is segmented into a number of phases or steps. Several attempts were predominantly *chronological* and suggested three phases: preliminary study, main study and implementation (Dopping 1972, Tongeren & Bubenko 1966). Other attempts were *systematic*, attempting to define the types of knowledge or methods needed (Langefors 1969). Still others proposed a *combination of chronologic and systematic phases*, currently known as life cycle models or project models (e.g. Davis 1974, Lundeberg et al 1978 & 1979, SIS 1975).

2.2.1 *Life cycle models*

The dominant approaches and currently the most popular conceptualizations of the process for designing computerized information systems are life cycle models (or project models). In these models computerized information systems are conceptualized as developing through a temporal sequence of stages - a "life cycle": a computer system is designed before it is implemented, tested after it is implemented, and maintained until it "dies" or is replaced. The life cycle model involves three fundamental ideas: a requirement specification, a universal design process, and finally allocation of design resources and decisions and design activities. It appears that the objective is to enable computerized information systems to be constructed as efficiently and routinely as products are manufactured as for example in mass production.

Computer system design is a complex task that is normally exposed to changes. It is given closure by laying down a specification of the information required by users, i.e. a specification of reports to be produced by a computerized information system. The requirements specification provides the boundary conditions for subsequent design and implementation steps.

The design process is universal. Every application needs to go through essentially the same steps when the application is conceived, developed and implemented. Neglecting any portion of the life cycle may have disastrous consequences for the end result. The life cycle models segment the process into a number of phases, and possibly steps. Basically, four phases may be delineated: initiation, investigation, construction and administration (Persson et al 1980). The number of phases and steps may, however, vary, and they may be described differently by different writers, but the differences are primarily editorial. Representative examples of segmentation of life cycle models are shown in Figure 2.1. In addition Figure 2.2 gives some representative examples of life cycle models with particular regard to the Scandinavian School, founded by Börje Langefors.

In the life cycle models there is an allocation of decisions and activities to steps in the design process and division of responsibilities between designers and users. The models are thus valuable tools for planning and controlling the design process. Some decisions or activities are postponed, others are advanced. This is done partly by defining the work to be done and partly by specifying the documents to be produced in each phase. Hence it is ensured that activities are carried out in a suitable order.

There are several short-comings in the life cycle model (Alloway 1977, Kling & Scacchi 1980, Lucas 1978a, 1978b).

First life cycle models are oriented primarily towards transaction processing systems and other computer systems which are based on automating existing routines. Design of decision support systems is ignored.

Further, such models ignore the fact that an organization may have several computer system projects concurrently. These projects may differ in terms of size, complexity, novelty etc. They may also be at different phases of the life cycle, hence aggravating the problems of planning and coordinating.

A third short-coming reflects a desire by many system designers to view computer system design as essentially technical and managerial in its focus. Hence attention is drawn to the different phases of the life cycle model independent of their organizational setting. The interest of designers in those matters which concern the user, is often limited to the design of user-oriented query languages, terminal procedures and devices for easy computer access; and appropriate training and instruction in the use of a computer system.

Blumenthal 1969	Preliminary analysis Feasibility assessment Management consideration Systems implementation and control Data processing organization activities
Davis 1974	Definition of the system or application – feasibility assessment – information analysis Physical design – system design – program development – procedure development Implementation – conversion – operation and maintenance – post audit
Lucas 1978b	Inception Feasibility study Systems analysis Design Specifications Programming Testing Training Conversion and installation Operations

Figure 2.1 Some representative examples of life cycle models

Langefors 1969	Choice of degree of ambition Strategy for implementation Information analysis Systems design Equipment selection and installation
Lundeberg, Goldkuhl & Nilsson 1979	Change analysis Information systems development — Analysis and design of information system . activity studies . information analysis . data system design . equipment adaptation — Realization of information system
SIS 1975	Feasibility study Object study Information study Processing study Systems study Detailed systems study Systems component design Systems implementation Post-implementation study

Figure 2.2 Some Scandinavian examples related to life cycle models

Fourth, the models of a computerized information system used during computer system design are often abstract and symbolic, hence the user may not develop an understanding of the system until towards the final phases of the design process. There is, however, a tendency to ignore changes in the information requested by users after laying down the specification for a computerized information system or after implementing it. Once implemented the pressure is to minimize system amendments. The designer is keen to tackle the challenge of the next application rather than service the current one.

The life cycle models further assume that computerized information systems and computer system design can be isolated from the organization. The impacts of computer system design on organizational processes are ignored, as well as the consequences of computerized information systems on organizational structure. Similarly no notice is taken of the influence of organizational characteristics on computerized information systems.

Finally, the last short-coming of the life cycle model is the emphasis it gives to the role of system

designer. The phases suggest that a system designer must be in charge of the process of computer system design since the designer alone has the tools and techniques for designing a computerized information system. The models largely disregard user involvement.

In order to improve the life cycle models and tackle some short-comings several modifications and amendments have been put forward. Some early attempts involve participative models, more recent attempts are experimental models and contingency approaches.

2.2.2 *Participative models*

Some of the limitations and shortcomings of the life cycle model may to some extent be removed by user involvement and participation in the design process.

For some time there has been a noticeable trend in favour of participation to be found in social science and management literature as well as in literature on computer system design. Participation has been advocated for several areas of organizational design and development. Suggestions for participation in computer system design are widespread (Dallinger 1975, DeBrabander & Edström 1977, Edström 1977, Hedberg 1975, Mumford & Henshall 1979, Mumford, Land & Hawgood 1978). Further Lundeberg et al (1978, 1979) following Langefors (1973) stress that documentation and design-methods must be user-oriented.

There are arguments for participation as well as some critical points against participation. Ager-snap (1978) distinguishes three sets of arguments in favour of participation: political, humanistic and efficiency rationales.

The political rationales argue that demands for participation are a question of equality. According to the humanistic arguments it is inconsistent with the independence and dignity of human beings to be treated as objects and not as subjects.

From the point of view of efficiency, participation is seen as a means towards other ends, and most of the arguments for participation presented in the literature belong to this efficiency category.

From a managerial point of view participation is usually seen to have two benefits in connection with organizational design and computer system design (Bjørn-Andersen & Hedberg 1977, Child 1977, Lucas 1975, Pfeffer 1978).

First by involving people in the design process, they may be more committed to the decision and more motivated to carry it out. Involvement may enable people to develop realistic expectations and reduce resistance to change.

Second, the quality of a computer system may be improved by involving people in the design process. Computerized information systems may be constructed upon erroneous premises, and user participation in the design process may give system designers better access to relevant data and hence improve the knowledge on which computerized information systems are built.

A number of criticisms from a management perspective can be found in the literature (Sackman in Bjørn-Andersen 1980, Child 1977). The critical points mostly refer to the time required, the quality of solutions, and values. Participation is time-consuming as it takes longer elapsed time and may take time from other tasks. It represents a risk of sub-optimization, of not arriving at the best solutions, and might imply a risk of compromising. Finally, participation may introduce values that are unacceptable to the organization and it may politicise the design process.

As the prescriptive, noncontingent orientation to participation has dominated the literature, the political aspect has largely been ignored. However, occasionally participation amounts to little

more than manipulation, in which workers are seduced into thinking they have participated in making a decision which turns out to be what management wanted to do in the first place. Alternatively participation may be used in delaying decisions and blocking changes. The manipulative side has slowly been recognized. A more idealistic and less manipulative attitude to participation is recommended by among others Lawrence (1954). He argues that participation is not only a matter of communication but a give-and-take-process involving mutual respect. Participation cannot be used for isolated decisions but it must be an ongoing process where it is essential how people are customarily treated (Lawrence 1954).

Critical aspects in participation are the distribution of power, influence and knowledge. It is recognized, that involvement in computer system design requires knowledge of computer technology, system design and system use, and that few managers and users possess such knowledge (Bjørn-Andersen & Hedberg 1977, Hedberg & Mumford 1975, Nygaard & Bergo 1975).

Several models for involving users in computer system design have been delineated. They may range from passive influence, where users are little more than objects to be studied by designers; to active influence, where design may be user controlled. In these cases, special attention may be given to the user interface and system quality may be evaluated by using user criteria (Bjørn-Andersen & Hedberg 1977, Eason et al 1974, Lucas 1974). However, Hedberg (1975) warns that user representatives in system design groups are likely to find themselves in one of two equally unattractive situations: they may become hostages or they may be exposed to indoctrination.

The extent of user involvement is closely related to the functions users can perform during computer system design. These functions may comprise authorization and control, analysis of user information needs, evaluation of system alternatives, job design, training etc (Eason et al 1974).

2.2.3 *Alternative system design models*

Life cycle models largely ignore changes in the information requirements of users which occur after laying down the specification for a computerized information system or after its implementation. Further it is difficult to develop an understanding of the computerized information system from the abstract and symbolic models utilized during computer system design. The organizational situation may, however, change and requests for reports to be produced by a computer system may change too as consumption is usually encouraged by using it.

A number of researchers have therefore recently proposed experimental approaches to computer system design. Starbuck (1975) and Lucas (1978a) have suggested *evolutionary designs* involving continual changing and revising of computerized information system. Earl (1978) suggests using *prototype systems*, which are simplified computer systems used in trial-and error processes, and others, similarly, suggest using *system sketches* based on the work of Staffan Persson (Broz 1981, Nilsson 1980, Persson & Strandler 1978). Further Hedberg and Jönsson (1978) suggest designing *semi-confusing information systems* where information systems are seen as sets of hypotheses that should be tested and elaborated.

Prototype systems are concrete and iconic models, their sole use is as vehicles for experimentation and exploration in an operational environment before the "production" system is developed. A prototype system affords opportunity to observe and examine information use. Prototype systems are designed and written quickly, and thus may be crude and rough; they test alternative designs, are improved and continually amended; and thus they may grow in complexity. Once the prototype has served its experimental purpose it will be replaced by a robust, and hopefully viable, computer system. It is critical that the prototype does not live for too long without review, it may therefore be necessary to declare the prototype's life-span in advance. In the process of designing computer systems the prototype system ideally fits in the systems analysis and system design phase.

Alloway (1977) argues that the task of creating computerized information systems has become increasingly ill-defined, unstructured, complex and uncertain, and that the traditional life cycle model, which Alloway (1977) calls a project model, is a barrier to success in unstructured projects. An alternative model, which Alloway calls a full life cycle model, is proposed. This model has four stages: strategic, managerial, operational and evaluation.

The strategic stage involves searching for and selecting new projects for computer systems in the same sense as organizations search for new products or new markets. The strategic stage ends when a project proposal has been accepted. In the managerial phase a practical plan for coordinating the cluster of means, integrating them with existing organizational realities, and designing the approach for the project is developed. The final part of the managerial stage continues in parallel with the operational stage and after the operational stage is over. The operational stage roughly corresponds to the life cycle model. The final stage, evaluation, is parallel to the other three stages. Evaluation feedback affects decision making in all three stages.

2.2.4 Summary

The life cycle models represent currently the dominant approaches for designing computerized information systems. They grew out of early attempts to improve the design process and its results. They have, however, a number of limitations and shortcomings.

The participative models represent some early amendments and modifications which attempt to cater for some limitations in the life cycle models. More recent attempts involve experimental models and a full life cycle model. These models are not mutually exclusive, for example, participation may be an essential element in experimental models and in the full life cycle model.

2.3 Methods and techniques of design

As can be seen from the previous section models for computer system design have developed from life cycle models, to participative models, and finally to experimental models, which represent the present stage of development of computer system design. A similar trend can be discerned on a more detailed level with regard to methods and techniques of computer system design.

Couger (1973) discerns four generations of techniques. They can be seen to provide increased capability of analysis and design, and to some extent grew out of both the increase in complexity of the applications on which system designers wanted to work, and the advances in information technology.

The *first* generation techniques consisted of flow-charts, block-diagrams and sundry forms. They were manual techniques. In the *second* generation techniques for flow-charting were standardized and improved, decision tables made their entry together with sundry matrixes representing relations between information sets. The aim was to use a precise description method having mathematics as an ideal. The first and second generation techniques were manual and they concentrated on individual systems.

The *third* generation is characterized partly by an increasing use of the computer as an aid in computer system design and partly by expanding the scope of system design to studying organizational procedures. There were three steps in using the computer as an aid in computer system design, from automation of existing manual techniques to development of decision table processors, and finally development of particular computer-aided techniques. Larger and more complex systems were modelled. The third generation coincided with proposals for total integrated MIS (Management Information System). Several computer manufacturers developed procedures for analysis, description and design. The aim was to use the system designers more efficiently. Attempts were made to have users specify the inputs and outputs of a computer system. The

system designers could then analyze and design the system without detailed knowledge of computers. The programmer took care of the rest. It can with some generalization be asserted that third generation techniques assumed that organizations existed under static and stable conditions and that specifications and computer systems could be frozen for several years ahead.

The *fourth* generation techniques were only in their infancy in 1973. Certain trends were believed to exist, hence it was expected that the techniques in each of the phases of system design would be integrated. Design would not only be computer-aided but computerized. Techniques for computerized design and optimization would increase the efficiency of computer system still more.

The assumptions behind the expected development of fourth generation techniques are a continuation of the predominant conditions during the third generation, i.e. centralized computer systems, large-scale technology and static applications. These conditions have been present as well as the contrary conditions, i.e. decentralized computer systems, small-scale technology and dynamic applications. Looking back, the fourth generation coincides further with an increasing emphasis on user participation and the entry of experimental models of design.

The four generations identified by Couger (1973) apparently only recognize computer system design as an exclusively technical problem and ignore work system design. However, techniques suitable for work system design have been developed (Land, Mumford & Hawgood 1980, Mumford 1981).

Among the currently used techniques for computer system design there are two important subsets. One subset involves tabular or matrix forms. The second subset involves graphical models or flowcharts.

Matrix-oriented design-techniques allow the manipulation of the design-problem by using matrix-algebraic methods (Harary et al 1965). Matrixes can be used to represent the information sets and their relations. By manipulating the matrixes the generation of information sets can be traced and design alternatives based on the structure and interdependence of information sets computed (Langefors 1963 & 1973, Lieberman 1956, Olerup 1974).

A matrix-representation of a design-problem can often be translated into a graphical representation, and vice versa. HIPO (Hierarchy, plus Input, Process, Output), IA (Information Analysis) and SADT (Structured Analysis and Design Technique) are examples of graphical techniques (Canning 1979, Katzan 1976, Lundeberg et al 1978 & 1979, Ross & Schoman 1977).

The most important characteristics of graphical techniques are the use of a notation and the hierarchical structure of systems. The notation comprises a set of primitive constructs or symbols and a syntax or rules for drawing diagrams. The system structure is seen as hierarchical and modular, which implies that graphs or diagrams are exploded, exposing more and more detail, hence indexation for cross-referencing is necessary, and further replacing modules and subsystems is facilitated.

2.4 The task and scope of computer system design

Previous sections in this chapter have dealt with the methodology, models and techniques for computer system design. The methodology and techniques chosen when designing a computerized information system are related to the perception and definition of the design task. This section will discuss approaches to identifying and defining information systems, which may be computerized.

The task of computer system design is often defined as designing a computerized information system that will provide users or decision-makers with required information. That certain reports,

or information, are required tends to be taken as a given, and thus as a specification of the computerized information system. A computerized information system is conceived essentially to be a machine for transforming data-inputs into data-outputs. The subsequent design-tasks involve the provision of solutions and tools (e.g. dialogues, databases and programs; computers, terminals and communication facilities) which are efficient in making the reports available. Implementation of the solutions developed requires human relations-skill and may be excluded from the design proper.

The rationale behind the notion that the aim of a computerized information system is to provide decision-makers with information is based on the conception of organizations as rational systems and the traditional concepts of planning and control. It further refers to the conceptualization of systems as recursive and hierarchical in which it is claimed that there is a universal way to view any system.

An organisation is assumed to have known and constant input and output relations. It is asserted, that the external properties of a system (i.e. those properties which are essential with regard to relations with other systems) are specified (Langefors & Samuelson 1976). This means that ideally from the point of view of efficient production, organizations should have a constant environment, and should not be influenced by extra-organizational factors.

An organization is regarded as a system of components, which are influenced and integrated by a control system towards the organizational goal. The organization further revises its actions based on a comparison of performance and goals (J. C. Emery 1969, Langefors 1970). Hence goals are important and procedures for identifying goals are needed. Elaborate models of theoretically deduced hierarchical goal structures of organizations have been suggested. Langefors (1970) proposes a model relating the operative goals for each operative component to the ultimate goals in consistent means-end-chains. For any organization, it is thus presumed that a set of ultimate goals exists, which determines an organization's desirable behaviour, and which is the point of departure when designing a control system (Langefors 1970).

An organization is decomposed, level by level, into subsystems and components, the procedure is repeated until the basic or operative components are reached (Langefors 1970 & 1973), in that way a specification of the control system level-by-level is arrived at.

The operative components are integrated towards the ultimate goal by transferring information. It is typically assumed that information requirements may be determined uniformly across the organization. This is done level by level with regard to the external properties, such as the goals, and the states of each subsystem. Hence the information requirements are determined through a means-end-analysis, vertically from the ultimate goals (Langefors 1970). In that way a complete specification of an information system is obtained. The procedure implies that an information system is assumed to be founded on neutral and given goals. Computerization then depends on the cost effectiveness of processing information with different technologies (Langefors 1970 & 1973).

The implications are that management needs more information, that information should be aggregated upwards, and that management does not need to know how an information system works. Information systems are considered as machines for transforming data, hence a mechanistic approach to designing computerized information systems is implied.

First, most managers do not have great informational needs, and receive much non-relevant information (Ackoff 1970, Gorry & Scott Morton 1971). Rather, they have need of new methods to understand and process the information already available.

Gorry and Scott Morton (1971) argue that neither the management control nor the strategic planning activities necessarily needs information that is a mere aggregation of data from the operative control data base. Further they argue that information systems built to support structured

decision making will be significantly different from those designed to assist managers in dealing with unstructured decisions.

The planning levels - strategic planning, management control and operational control (Anthony 1965) - will differ with regard to the characteristics of the information needed. The information needed will be aggregate at the strategic level and detailed at the operational level, it will be obtained from external and internal sources respectively, and have a large and narrow scope respectively. The information characteristics at the management control level fall between the extremes of strategic planning and operational control.

The degree of structure of decisions refer to the distinction between programmed and non-programmed decisions (Simon 1965 & 1977). In a very structured situation much if not all of the decision making can be automated. In the unstructured case, the human decision maker must provide judgment and evaluation as well as insights into problem definition.

By cross-classifying planning levels and the degree of structuredness of decisions a framework for characterizing organizational activities in terms of the types of decisions involved, is obtained. The framework implies differences with regard to system design, project organization, and the types of decision models involved.

Second, if a manager does not know how an information system works, he/she will be controlled by it (Ackoff 1970). It can be argued that a manager's or user's knowledge of an information system is related to the design approach.

Swanson (1976) suggests three approaches to the conception of information systems: a mechanistic approach, a utilitarian approach and a reflective approach. In the mechanistic approach an information system is conceived essentially as a machine for transforming data - a data processing system - the aim is to design tools which are efficient in making reports available. The weakness of the mechanistic approach is that the user of the data, the decision maker who is to be informed by the information system, is essentially excluded from the design itself.

In the utilitarian approach the user is integrated into the design of an information system. A user's information needs may then be assessed by measuring the "utility" which potential information provides. This suggests that the question of information needs can be addressed through an examination of the decision situations faced by the users of the information system.

Information systems often fail to be implemented because of communication gaps between user and designer. The user may have difficulties in specifying his information requirements, or the designer may have failed to ascertain a user's true intentions. It is not only true that the user must understand the designer, the designer must also understand the user. Both the user and the designer are therefore included in the information system in the reflective approach.

2.5 Contingency approaches to computer system design

The frameworks developed by Gorry and Scott Morton (1971) and Swanson (1976) suggest that computerized information systems and their design need to be considered within more comprehensive frameworks. Further they indicate differences with regard to decision situations and approaches to information systems. These differences are, however, not related to other factors. It appears, then, that contingency approaches to computer system design may prove fruitful extensions.

A number of contingency frameworks for computer system design have been proposed, in the literature. They are listed in Figure 2.3, and discussed below.

Author(s)	Contingency variables	System design variables
Alloway 1976	design-task organizational context	strategy for computer system design
Björn-Andersen 1974	rational economic man administrative man muddling through model	user-participation method of analysis tools of analysis objects of analysis implementation size flexibility
Ciborra, Bracchi & Maggiolini 1980	decision process data processing technology user's design-task consciousness project management	systems analysis methods
McKeen, Nauman & Davis 1979	project size degree of structuredness user-task comprehension developer-task proficiency	information requirements are given information requirements determined linearly information requirements determined recursively information requirements determined experimentally
Taggart & Tharp 1975, Tharp & Taggart 1976	analyst's skills analysis situation	MIRA-techniques

Figure 2.3 Some contingency-approaches to computer system design

Alloway (1976) collected data on twenty diverse computerized information systems. He found that the success of a strategy for computer system design was contingent on the nature of the design task and on the organizational context. The nature of the task refers to the objectives of The design task and the skills used to meet the objectives. The organizational context refers to the differentiation and integration of EDP and user departments.

Bjørn-Andersen (1974) argues that the characteristics of the strategy for design and implementation are related to models involving different aspects of man as decision maker. Three such models are examined: rational economic man, administrative man (Simon 1957), and the muddling through model (Hirschman & Lindblom 1962, Lindblom 1959). Seven system design variables are suggested. User participation, for example is not required, if rational economic man is assumed; it is important if administrative man is assumed; and finally, when a muddling through model is assumed, design is required to be user controlled.

Ciborra, Bracchi and Maggolino (1980) argue that the choice of suitable system analysis methods depends on four criteria: the nature of the decision process, data processing technology, users' design-task consciousness, and the type of project management system. They examine a number of system analysis methods (including IA, SADT, HIPO and others) which are scored with regard to the four criteria. Methods are considered more flexible, the higher the score given. They conclude that very few methods show a high degree of flexibility to adapt to multiple social and technical contingencies (Ciborra et al 1980). They are in effect arguing that system analysis methods need to be general.

McKeen, Nauman and Davis (1979) proposed a contingency framework for choosing a suitable method for determining information requirements, i.e. one of the early phases in a life cycle model. The information requirements may be given, they can be determined linearly, recursively or experimentally depending on the level of uncertainty. The level of uncertainty is influenced by project size, degree of structuredness, user-task comprehension and developer-task proficiency.

Finally, an elaborate procedure, the Situational Perspective on Information Requirements Analysis (Taggart & Tharp 1975, Tharp & Taggart 1976), is proposed. Basically the intention is to choose appropriate MIRA-techniques (techniques for Management Information Requirements Analysis) with regard to the analyst's skills and the analysis situation. MIRA-techniques as well as analyst's skills and the analysis situation are evaluated with regard to four groups of parameters: development process, information, decision-making and organizational parameters. Analyst's skills and analysis situation are diagnosed by means of questionnaires administered to users and designers.

The approaches lend some support to the idea that contingency approaches are relevant with regard to computer system design. However, they largely lack empirical support. Further, it is doubtful, whether they all are properly contingency approaches (e.g. Ciborra et al 1980, Taggart & Tharp 1975, Tharp & Taggart 1976).

The most significant weakness in the approaches discussed is that they are limited in terms of the contextual factors considered, these are mostly made up of analyst's skill or task-comprehension and analysis situation.

Contingency approaches have been influential with regard to the study of organizational structure. The results obtained from this research suggest that factors related to organizational context may be influential with regard to computer system design and computerized information systems.

2.6 Summary

In this chapter computer system design has been reviewed. Models and methods for computer

system design are important as they determine the characteristics of computerized information systems.

Different approaches to the design process were noted. Although it was recognized that problems may lead to solutions or solutions may be looking for problems a study based on the latter approach requires extensive and longitudinal empirical data. Hence the discussion was limited to first the simple problem solving model and second to normative models.

Life cycle models still represent the dominant approaches when designing computerized information systems. Several shortcomings in the models were noted. The participative models provide the first attempts to amend some limitations of the life cycle models. More recent attempts are termed experimental models.

Finally a number of contingency approaches to computer system design were briefly reviewed. They were found limited with regard to the contingency factors considered as well as being insufficiently grounded in available research on organizational structure using a contingency approach.

3. ORGANIZATIONAL STRUCTURE AND CONTEXT

The study and design of organizational structures is an established topic which has passed through a number of stages of inquiry. The current stage is characterized by a number of schools of thought. Classical management theory was long an important school, but has been superceded by other schools of thought, including contingency theory, which has been particularly important in questioning the idea that there is one best way to administer all organizations.

Three classes of determinants, or contextual factors, of organizational structures have been examined in the literature: size, environment and technology. Although there are important differences in the definitions and operational measures used, systematic relationships between each of the factors and organizational structure have been demonstrated. It is, however, becoming increasingly clear that there are several limitations in contingency theory and that the theory faces considerable problems.

Nevertheless, despite such limitations, contingency theory has gone a long way in furthering our understanding of organizations. It has indicated the crucial role of uncertainty and information in organizations as determinants of organizational structure. The structure of an organization is, then, taken to comprise all the tangible and regularly occurring features which help to shape the behaviour of individuals and groups in the organization.

This chapter starts with a brief review of two schools of thought on organizations: classical management theory and contingency theory. Two fundamental concepts, information and uncertainty, are examined with regard to their main areas of use. Next the limitations of contingency theory and their importance with regard to the study of computerized information systems are discussed.

Finally, three contextual factors - size, environment and technology - are examined with regard to conceptualizations and definitions used. The purpose is to suggest ways of conceptualizing environment and technology in the context of developing a contingency framework computerized information systems.

3.1 Determinants of organizational structure

There is a long and extensive tradition of research on organizational structure, i.e. the allocation of authority and work roles and the administrative mechanisms needed to control and coordinate work activities. Within this tradition two major schools can be identified. These are classical

management theory, which is the oldest school, and contingency theory.

Classical management theory attempted to identify basic principles for defining an optimal organizational structure. The principles were to lead to a controlled and orderly organization. It was assumed that if the organization was managed correctly internally then the firm would be tuned correctly to the requirements of its environment and technology, although little attention is paid to the nature of the relationships between the firm and those factors. The internal order and stability is accomplished by means of the hierarchy, which is the mechanism used for distributing authority and decomposing goals. In this way legitimate authority is straightforwardly distributed from the apex to the base of the pyramid. Similarly, the form and content of organizational goals are regarded as unproblematic and their decomposition to various parts of the organization is considered a relatively simple matter to be achieved by means of the hierarchy. The hierarchy is complemented by a set of information systems whose efficient operation rests upon their ability to adequately represent and interpret the higher-order or ultimate goals. Together the information systems and the hierarchy ensure that local decisions are made and coordinated in accordance with a higher-order rationality.

Contingency theory has developed from the gradual realization that a wide range of effective organizations can be observed and it claims that there is no one best way to organize and that any way of organizing is not equally effective. Empirical and conceptual research efforts have attempted to discover the extent and degree of variation in organizational structures and to establish the conditions of such variation (Burns & Stalker 1966, Lawrence & Lorsch 1967, Pugh & Hickson 1976, Thompson 1967, Woodward 1965).

Contingency theory emphasizes that an organization needs to identify and respond to contextual factors. In the simple models, little more than positively found associations between structural and contextual factors are explicated. These models then go on to suggest that the contextual factors determine structural variables because of certain, primarily economic, constraints the former are assumed to impose.

In the more complex models, the concept of uncertainty is introduced. The argument is more detailed and can be summarized as follows. Survival of an organization depends on its ability to recognize, identify, discriminate and evaluate all relevant conditions and variables. Further, an organization needs to respond to the essential variables that most affect their viable operation. Finally, the organization needs to do this by altering its internal structure in order to enable it to respond more effectively to the demands posed. In the complex models, the contextual factors are seen as sources of uncertainty, imposing constraints and offering opportunities.

A review of the literature on contingency theory reveals that there are basically two approaches to the isolation and identification of contextual factors, either a number of given factors are used or a determination of the relevant factors is part of the analysis. In the first approach which has had most influence the factors primarily used are environment, technology and size.

In summary, the determinants of organizational structures are higher-order goals in classical management theory and contextual factors in contingency theory.

Uncertainty is ignored by the classical management theory, but treated as a central concept in contingency theory.

Classical management theory gives no attention to the influence of factors other than goals. Hence it is insufficient for studying the effect of environment and technology on structural features such as information systems.

3.2 Uncertainty and information

Uncertainty and information are currently considered as central concepts in management and be-

havioural science literature. The concepts are closely related. The main uses of the terms occur within three areas: the mathematical theory of communication, operations research and statistical decision theory and finally within organizational and behavioural studies.

In the mathematical theory of communication, sometimes referred to as information theory (Shannon & Weaver 1949), information and the probability of a message are related, the lower the probability of a message the more information received. Information is measured quantitatively in terms of bits. The theory has found practical application in the design of codes for transmitting messages. The model used identifies a set of messages (with probabilities), a source, a channel for transmitting the messages and a receiver. Each message is given an optimal code depending on its frequency in order to use the channel efficiently (Abramson 1963). In a very literal sense, more information is received when the message is infrequent as a longer code, i.e. more signals, is necessary. The theory of communication is relevant on the technical level of communication. It has been argued that the literal use of the term information is misleading and therefore it is suggested that the designation 'theory of signal transmission' is more appropriate (Bar Hillel 1964).

Statistical decision theory is concerned with the choice of strategies under different states of nature. Three types of decision situations are distinguished. They are decisions under certainty, decisions under risk and decisions under uncertainty. In conditions of certainty, it is known which outcome will occur. Under risk, the outcomes are not certain but the probabilities of the alternative outcomes are known, thus the strategy with the highest expected mean outcome is chosen. Finally, in conditions of uncertainty the unknown outcomes cannot be predicted even in probabilistic terms. It is, however, commonly assumed that the decision maker has enough information to construct a pay off matrix but not to assign probabilities to the outcomes. In this case several criteria of choice have been suggested. These include the Wald, Hurwics, Savage and Bayes criteria (Baumol 1965).

The theory of communication and the statistical decision theory have several common features. First, they both aim at a quantitative treatment of information and uncertainty. In doing so, both theories pre-suppose the availability of considerable amounts of information. Second, they both ignore the content and meaning of information, i.e. of messages and events respectively. Hence, both theories take an unduly narrow perspective on uncertainty and on information, and as a result, prove insufficient in many actual decision-situations in organizations. For example, they focus on the mathematical aspects, such as an individual's ability or inability to assign probabilities to alternative outcomes, which is but one component of uncertainty.

In the third area, of organizational and behavioural studies, the conceptions of uncertainty and information are wider and more varied.

Most researchers into the concept of uncertainty are not interested in uncertainty alone but in the relationship between uncertainty and amount of information. Uncertainty is seen as referring to lack of knowledge or to unpredictability and information is seen as related to the reduction of uncertainty.

However, some qualifications are necessary before proceeding to definitions of uncertainty. First, Pfeffer (1978) argues that uncertainty must concern those events that have consequences for the organization. Uncertainty, then, is problematic only when it occurs along with organisational dependence. Second, Pfeffer (1978) argues that uncertainty is unplanned or unpredictable variation. To the extent that change and variation are predictable there is no uncertainty. Third, Nyström (1974) distinguishes between situations of genuine uncertainty, characterized by lack of information (or by incomplete information), and other situations of uncertainty, which are characterized by incorrect information.

Galbraith (1973) argues that the basic effect of uncertainty is to limit the ability of the organization to preplan or to make decisions about activities in advance of their execution. The greater

the uncertainty of the task the greater the amount of information that has to be processed during its execution. Hence, uncertainty is defined as the difference between the amount of information required to perform the task and the amount of information already possessed by the organization (Galbraith 1973).

Lawrence and Lorsch (1967) take a more detailed view and state that uncertainty consists of three elements. The lack of clarity of information, which implies an absence of specific and relevant information. Another element is the long time span of feedback, where there may be an interval of several months or years before the results of decisions and actions are known. Finally, the general uncertainty of causal relationships which implies that consequences of decisions and actions are difficult to identify.

Duncan (1972) criticizes Lawrence and Lorsch (1967) for being vague in their definitions of the elements of uncertainty. Duncan (1972) suggests that there are three elements in uncertainty. Two elements are: the lack of information regarding environmental factors and not knowing the outcome of a specific decision (in terms of potential losses). These elements are similar to the three elements identified by Lawrence and Lorsch (1967). The third element suggested by Duncan (1972) is the inability to assign probabilities with any degree of confidence. Hence probabilities can be assigned to the outcomes of events under conditions of uncertainty but with less confidence than under conditions of risk. This is different from conditions of uncertainty in statistical decision theory where probabilities could not be assigned.

It is sometimes suggested that uncertainty and unpredictability are equivalent and that complexity is separate from uncertainty. However, several authors when discussing environmental and technological uncertainty (Emery & Trist 1965, Terreberry 1968, Thompson 1967, Perrow 1970, Duncan 1972) discern two dimensions: complexity and dynamism. Hence it is proposed that uncertainty has two dimensions: complexity and dynamism. Complexity refers to the number, variety and interconnectedness of factors that impinge on a decision. Dynamism refers to whether the factors and interconnections remain the same over time or are in a process of change. It has been found that dynamism contributes more toward uncertainty than does complexity (Duncan 1972).

If uncertainty is lack of knowledge, then information can be regarded as something that makes choice possible. While most authors regard amount of information and uncertainty as related, they offer no definitions of information. Ackoff (1958) defines the amount of information communicated as the difference between the amount of information the decision maker has after receiving some communication and the amount of information the decision maker had before. Galbraith's (1973) definition of uncertainty is obviously a parallel to Ackoff's (1958) definition of information.

In conclusion the definitions of information and uncertainty suggested by the theory of communication and the statistical decision theory are too narrow. Instead, the use of a wider definition is proposed, incorporating the qualifications noted (dependency, unpredictability, genuineness) by Galbraith (1973) and Duncan (1972). *Uncertainty* is defined as the difference between available and required knowledge and is made up of three elements. Complexity and dynamism are seen as dimensions of uncertainty. *Information* is regarded as reducing uncertainty or, as increasing knowledge.

3.3 Limitations of the contingency approach

There are several difficulties with and arguments against contingency theory and contingency studies. These can be considered under a number of headings.

- how organizations cope with uncertainty
- definition of factors, variables and functional relations

- organizational performance
- strategic choice

After reviewing these aspects it will be argued that there are two perspectives for analyzing organizations that pose different questions.

Contingency theory generally assumes that organizations attempt to adapt to uncertainty through effective scanning mechanisms (Aguilar 1967) and flexible structures. However, Cyert and March (1963) argued that organizations seek to avoid and absorb uncertainty, for example by ignoring factors that cannot be predicted, by using standard operating procedures and by negotiating environments. If the uncertainty can neither be absorbed nor avoided, organizations may attempt to isolate its effects by segmenting the organization, for example by creating self-contained tasks (Galbraith 1973) or by setting up special units (Pfeffer 1978).

Assuming that organizations attempt to adapt to uncertainty, there are however some difficulties with the ways in which the variables and the functional relationships between them have been treated in the literature.

Most of the studies which adopt a contingency approach are limited to an investigation of one contextual factor and its impact on the organization. In doing so, this approach ignores the fact that organizations can themselves influence these contextual variables as well as be affected by them. Organizations may also ignore contextual factors, for example in situations where they have excess resources. Thus it is argued that for a contextual factor to have any impact, the organization must be dependent on that factor to at least some degree.

Furthermore, since there are usually several contextual factors which are relevant for each organization, these factors may affect the organization in contradictory as well as in neutralizing ways. Their impact may be differential, i.e. at different levels or parts of an organization. For example, technology is probably the most influential factor in core-activities, while size may have relatively greater impact on non-core-activities. Thompson (1967) and Woodward (1965) are primarily interested in core-activities and consider technology before size, while Pugh and Hickson (1976) are interested in non-core-activities and consider size more important than technology. The differences between these researchers may also be dependent on the way technology is conceptualized in their work.

Organizations may also operate in several contexts, each with a set of contextual factors. According to the theory, the organization needs to be structured with regard to each of these contexts although this may involve conflicting contingencies. At the same time, however, it is suggested that the structure of an organization needs to be consistent.

It is a basic assumption of contingency theory that an organization is structured in order to improve performance. However, performance is not always included in the studies, due to difficulties of measuring and operationalizing it and to finding measures that are compatible across organizations. It is not certain that an organization that shows poor results on some performance-measure is less efficient or less effective than other organizations. The critical question becomes not how organizations perform but rather whose preferences and interests are to be served by the organization and, particularly, which are critical.

It is assumed that mechanistic structures contribute towards poor performance though the relationship may well be the other way round: the mechanistic structure is the medicine to cure the poor performing organization. Mechanistic structures may also reflect the tendency to centralize decision-making and tighten control which are typical managerial responses to poor performance (Child 1977). In so far as more elaborate integrative or lateral mechanisms are more expensive, it is possible that their non-adoption partly reflects an existing condition of poor performance and low organizational slack.

Due to the problems and pitfalls which surround the concept of performance, it appears that the thrust of the argument in contingency theory is based on the law of requisite variety (Ashby 1965). According to the law of requisite variety, only variety can destroy variety. It follows then that in order to improve performance, an organization needs to adapt to uncertainty: the more uncertainty an organization encounters, the more adaptable its structure needs to be. This means that organic structures are favoured, particularly in conjunction with the argument of increasing environmental turbulence (Emery & Trist 1965, Terreberry 1968). It has been noted that the literature on organization design has been biased in favour of organic, lateral, non-bureaucratic structures (Pfeffer 1978). It seems as if researchers have a tendency to favour organic structures in contrast to those preferred by management.

The influence of non-organizational variables may often be important with regard to performance. Further, instead of assuming that structure leads to performance, performance may lead to structure (Child 1977). In conditions of poor performance, some organizations cannot afford to let the structure be affected by contextual factors to a full extent. In conditions of good performance, some organizations may be less dependent upon their contexts, and in a more secure position with respect to maintaining their target levels of performance.

Child (1972) has raised the fundamental objection that contextual factors are not only constraints, as they are usually treated in contingency theory, but they may be chosen. He therefore introduced the concept of strategic choice. Then the relations between structure and contextual factors are valid under one strategy. Further Weick (1969, 1979) argues that instead of adapting to a ready-made environment it is entirely possible that organizations themselves create or select the environment to which they adapt. The concept of *enacted environment* is therefore introduced.

Two complementary perspectives for analysing organizations can be contrasted. They are the rational and the political perspective. The rational perspective considers the appropriateness of a given structure for the coordination of interdependent elements in order to achieve some task. The rational perspective has dominated in contingency theory.

The political perspective, by contrast, studies why and how structure is a result of organizational influence processes. It further asks the consequences of a given structure for the distribution of control and power within organizations. The study of strategic choice as suggested by Child (1972) takes a political view.

The question that needs to be answered is whether the limitations reviewed here require us to reject completely the idea that there are environmental, technological and other factors which influence organizational structure and outcomes. The answer must be negative, since it depends on the timescale and the level with which the analysis is concerned. In the short term, the contextual factors may pose constraints, though in the longer terms these too may be subject to choice (Child 1972). Similarly, there is a sequence of choices, each choice being more constraining and at a more detailed level than the preceding one. Hence, the implication is that contingency theory is best considered as a partial theory, particularly relevant in situations of constrained choice.

In the short run with regard to computerized information systems the limitations of contingency theory can be ignored. A computerized information system usually implies that choices have been made concerning markets, products, suppliers, production methods etc. The situation can therefore be described as characterized by constrained choice and by the enactment of a particular environment. Hence, in the short run computerized information systems may be influenced by contextual factors.

3.4 Three contingency-factors

There are basically two approaches to the isolation and definition of contextual factors: either

they are selected and specified in advance or determination of the relevant factors is part of the analysis. When the contextual factors have been predetermined, the three most commonly identified are: size, environment and technology. Other factors include organizational members (Lorsch & Morse 1974).

The three factors - size, environment and technology - are reviewed below. The present study is however limited to environment and technology.

3.4.1. Size and growth

Organizational size and growth constitute important criteria for evaluating and ranking organizations (as is evidenced by their use in many business and management magazines). There are several ways of measuring the size of an organization, including total number of employees, number of sites, net assets and sales turnover. Most researchers have used the total number of employees as the main indicator of size.

Organizational size has a long history within the study of organizations. The relationship between organizational structure and size is strongly emphasized. Studies have investigated the relation between size and such structural features as "bureaucracy" and the number of levels in organization.

Very briefly, recent empirical research has shown a strong positive correlation between size and "bureaucracy" (Pugh & Hickson 1976). Child (1973) argues that size is a major but not the only important predictor of organizational structure. He further argues that complexity of an organization is a mediating factor between predictors of structure, including size, and variables of structure.

It has been found that the maximum length of the hierarchy varies in a very predictable manner with the total size of organizations. As organizations grow from small units their number of levels rises. The rate of increase in levels is however a decreasing one. There is a break in the increase of levels at about one thousand employees, the curve rises rapidly until about 1000 employees and about six levels and then flattens out: even at ten thousand employees there are only seven or eight hierarchical levels (Child 1977).

However, it is not only size that is important but growth because growth generates problems of control that require structural adaptation. There are several reasons for growth. It is necessary for survival and protecting the competitive position of the company; it is necessary for attracting and retaining high quality managers; and growth is a consequence of success (Child 1977).

The relationship of size and organizational structure cannot be regarded as deterministic. First, it can be modified by subdividing a large unit into smaller self-contained, or quasi-independent ones, for example by divisionalizing (Galbraith 1973). Second, other contingency factors (such as the degree of environmental variability) may influence the need to adapt organizational structure to size (Child 1974 & 1977).

Third it seems likely that size will influence the character of some subsets more than others, in particular higher levels will be more influenced than lower levels.

Organizational size is of importance with regard to problems of control and communication and the possibilities for solving these (Weick 1969). Williamson (1970) argues that an increasing number of levels implies a control loss, in so far as transmitting of information is characterized by cumulative losses. It will be argued later (chapter 4) that this will influence formalized information systems and the use of computers.

3.4.2 Environment

Katz and Kahn (1966) have described organizations as open systems and elaborated the implications of this view in some detail. Briefly, organizations engage in a cycle in which they acquire inputs (such as capital, raw materials and labour), produce some set of goods and services, and then deliver these goods or services back into the environment. The cycle of acquiring, converting and disposing of products means that the organization must depend on other groups and organizations both in the input-acquisition and in the output-disposal phase of the cycle.

The maintenance of organizations depends upon some degree of exchange with outside parties. Hence the structure of the organization is influenced by the environment and, conversely, the environment is influenced by the organization. Organizations are assumed to need to design their structures in terms of the law of requisite variety.

Burns and Stalker (1966) examined some Scottish and English firms, mainly within the electronics industry. Their work focussed on how the pattern of management practices in the companies was related to certain facets of their external environment. They were particularly interested in the rates of change in the scientific techniques and markets of the selected industries.

They identified two polar types of organizational structure: the mechanistic and the organic structure which are appropriate under different conditions. Briefly, the mechanistic structure is characterized by an emphasis on hierarchical relationships, formal communication channels, precise definition of roles and duties, and a highly standardized set of procedures. The organic structure, in contrast, is highly flexible and de-emphasizes bureaucratic attributes. It is characterized by a strong tendency for lateral communication, role diffuseness and participation in decision-making. The mechanistic structure appeared to be appropriate to an enterprise operating under relatively stable conditions while the organic structure appeared to be suitable for conditions of change.

Lawrence and Lorsch (1967 & 1969) studied a number of companies in three industries: plastics, food and container. The plastics industry had the most dynamic environment and the container industry the most stable. They emphasized the states of differentiation and integration in organizations. Differentiation refers to the existence of differences between managers in their orientations to time, goals and interpersonal relations. Integration refers to the quality of the state of collaboration that exists among departments. The integrative devices include hierarchical referral, standardization of routines and lateral relations.

In the dynamic environment, characterized by considerable market and technological change and by high uncertainty about future developments, the departments were highly differentiated. Research departments had to work to long time horizons, marketing departments against shorter time horizons than research but longer than production departments. In the more stable environments the required degree of difference between functional departments was less.

The higher the differentiation between departments the more difficult it was for them to achieve integrated effort. The high performing companies in each environment had developed the required degree of differentiation and they had also achieved the required degree of integration. The type of mechanisms used and the location of points of integration within the organization varied according to the contingencies faced by firms in the different industries. Integration in the dynamic environment required several integrative devices and extensive lateral mechanisms, while integration in stable environments was achieved primarily through the managerial hierarchy.

Dill (1958), in a study of two Norwegian firms, treats the environment as consisting of four groups of elements. These include customers, suppliers, competitors and regulatory groups. He compares the constraints and demands placed on managerial autonomy in the two firms by several environmental aspects and finds significant differences between the firms in their structures. Organization Alpha, in comparison to organization Beta, faces a more stable environment, fewer

demands for personal interaction of top executives with members of the environment, and inputs could be routed more directly and in standard ways. Lower complexity meant that a lower degree of managerial skill was required and environmental inputs were less disruptive to the organization in the long run. In organization Alpha there was more centralization of decision-making, more interdependence among departments, less specialization of activities, and more competition for scarce organizational resources.

The three studies present consistent findings on the relationship required between organizational structure and environment. Further, they all distinguish two dimensions of environment: first they characterize environments as more stable or as more dynamic, second they note the complexity of environments. In his work, Dill (1958) extends this distinction to include a number of environmental components.

Duncan (1972) takes this approach some steps forward. He defines the environment as "the totality of physical and social factors that are taken directly into consideration in the decision-making behaviour of individuals in the organization" (Duncan 1972). His unit of analysis is an organizational decision unit. A unit's environment is characterized as either internal or external and as composed of two basic dimensions. The internal environment (referring to factors within the boundaries of the organization) is made up of three components: personnel, functional and staff units and organizational level. The external environment (consisting of factors outside the boundaries of the organization) is made up of five components: customers, suppliers, competitors, socio-political or regulatory groups, and a technological component. The dimensions identified are the simple-complex and the static-dynamic. Complexity refers to the number of factors and their degree of similarity. Dynamism refers to the degree of change in the factors of the environment. The static-dynamic dimension is suggested to contribute more towards uncertainty than complexity.

These studies represent attempts to empirically investigate the relations between organizational structure and environment. There are also attempts to construct *a priori* environmental typologies and to speculate about their organizational correlates (Emery & Trist 1965, Thompson 1967).

Thompson (1967) suggests four types of environments based on the static-dynamic and the simple-complex dimensions. In a static and simple environment he suggests that an organization would have few functional units and rely on standardized rules and procedures. With increasing environmental complexity the functional units would be segmented corresponding to relatively homogeneous segments of the environment. With increasing environmental dynamism the organization will rely more on planning and less on standardized responses. In a dynamic and complex environment an organization would have boundary-spanning units differentiated to correspond to segments of the environment, and each segment would operate on a decentralized basis to monitor and plan responses in its sector.

Emery and Trist (1965) identify four types of causal texture of environments. The four types are: the placid, randomized environment; the placid, clustered environment; the disturbed, reactive environment; and the turbulent environment. In the placid, randomized environment the goals and noxiants are relatively unchanging in themselves and are randomly distributed. In the placid, clustered environments the goals and noxiants are not randomly distributed but cluster together. Both these environments are static.

The disturbed, reactive environment is dynamic. It consists of a clustered environment, made up of more than one system of the same kind. Organizations seek to improve their own position by hindering competing organizations. In the turbulent environments the dynamic properties arise not only from the interaction of identifiable component systems but also from the field itself. Organizations need to establish collaborative values and to enter into collaborative and cooperative relations.

Hence, the four types of environments suggested by Emery and Trist (1965) can be seen to refer to two fundamental dimensions. The dimensions are: complexity, i.e. the number of elements and

their interconnectedness, and dynamism (degree as well as form).

Emery and Trist (1965) argue that organizations will increasingly find themselves in turbulent environments. Similarly, Terreberry (1968) argues that environments are becoming more turbulent and uncertain. Brodén (1976) suggests a model for studying the development of turbulent environments, based on Emery and Trist (1965). The suggested approach implies representing processes in the environment of some focal organization as relations and changes in relations among components in the environment.

Environmental dimensions similar to complexity and dynamism have been suggested, as well as additional ones. Child (1977) suggests that variability and complexity are important environmental dimensions. Variability in the environment refers to the presence of changes that are relatively difficult to predict and involve important departures from previous conditions. Such changes are, therefore, likely to generate considerable uncertainty. Complexity of the environment is said to be greater the more extensive and diversified the range of an organization's activities is.

Khandwalla (1977) suggests five environmental attributes: turbulence, hostility, diversity, technical complexity and restrictiveness.

A *turbulent* environment (opposite stable) is unpredictable and fluctuating, it is rapidly changing and growing. An environment is likely to be perceived as turbulent, when there is a high rate of technological change (new products and/or new processes); when it is highly competitive; when there are large swings in economic activity.

A *hostile* environment (opposite benign) is risky and dominant. There are few profitable opportunities. An environment is likely to be perceived as hostile, when there are severe price-competition or stringent budgets.

An environment is *diverse* or heterogeneous (opposite homogeneous) if the organization directs itself to markets having separate characteristics and needs. Typically a diversified or large organization tends to have a diverse environment, as it serves a variety of markets for its products or services. Khandwalla (1977) refers to environmental differentiation, when the environments of different subsystems in an organization (for example, production, research, marketing) are very diverse.

An environment is *technically complex*, when techniques are rapidly developing, or when technologies are extremely capital intensive and automated.

In a *restrictive* environment an organization must operate under many constraints. These constraints may be legal, such as pollution laws; they may be political; they may be economic, for example scarce critical inputs; and they can be cultural. Restrictions may be imposed on an organization because of its monopoly nature or because it serves vital public interests. A restrictive environment is a complex one.

The environmental dimensions suggested by Khandwalla (1977) correspond to a large extent with those suggested elsewhere. They contain, however, a technological component, in terms of the dimension of technical complexity as well as technical change as a contributing factor with regard to turbulence. Further there are overlaps among the dimensions, for example between technical complexity and turbulence, diversity and restrictiveness both of which refer to complexity.

The discussion so far has been limited to components and dimensions of environments. Another set of problems surrounds the ways in which the limits or boundaries of the environment are established.

The distinction between different environmental boundaries proceeding outwards from the organization is essential. The environment of an organization cannot be satisfactorily defined without

reference to an organizational domain (Levine & White 1961, Thompson 1967). This consists of the specific goals (products and services) an organization wishes to pursue and the population an organization serves. Different segments of the environment have been distinguished in terms of their immediacy for the goals or functions ascribed to an organization. In this context the concept of task environment has been introduced (Dill 1958, Thompson 1967).

Further, the distinction between an organization and its environment is relative to the goals and actions of organizational decision-makers. Starbuck (1976) shows how differences may arise in what falls inside or outside an organization and consequently in the delimitation of the organization; similarly there may be differences between environments of organizational subsystems.

The delimitation of an environment has implications for the choice of components in the environment of an organization. In this study the environment is defined with particular regard to acquiring, converting and disposing of materials and products. Hence four environmental components are discerned: customers, suppliers, competitors and regulatory groups.

In this study technology is considered as separate from environment. Hence, the environmental dimensions considered do not include a technological component, therefore technical complexity is not considered. The environmental dimensions suggested are: changeability, complexity, hostility and restrictiveness.

Changeability refers to the degree and frequency of changes in the environment. It corresponds to the dimension static-dynamic or stable-dynamic¹⁾ which is either discussed in much research (Burns & Stalker 1966, Dill 1958, Duncan 1972, Lawrence & Lorsch 1967, Thompson 1967) or can be inferred from the analysis (Emery & Trist 1965). Changes may occur in both the composition and motion of an environment. However no distinctions are made in this study between these two types of changes, hence the term changeability is preferred. Changeability is further related to the concept of variability (Child 1977) and of turbulence (Khandwalla 1977) as they are used to characterize changing environments.

Complexity refers to the variety and similarity of the environmental components. An environmental component is considered complex when it consists of many and dissimilar groups; it is considered simple when the groups are few and/or have similar characteristics. Complexity corresponds closely with diversity (Khandwalla 1977), but also with complexity as used elsewhere (Burns & Stalker 1966, Dill 1958, Lawrence & Lorsch 1967, Thompson 1967).

The term *hostile*, and its opposite *benevolent*, refers to the degree of competition and the number of sales opportunities. The terms *lean* and *rich* may be used synonymously with *hostile* and *benevolent* respectively. An environment is considered *hostile* when there are few sales opportunities and when competition undermines the market for an organization. The concept *hostile* hence corresponds to *hostility* used by Khandwalla (1977).

Restrictiveness refers to the presence of regulations of different aspects of an organization. Regulations may take several forms, including legal, political; they may further involve agreements with the government. Regulations may be general, i.e. directed towards all industries or all organizations, or they may be specific, i.e. directed towards particular industries or organizations. Specific regulations result in marked distinctions in the kind and degree of environmental restrictiveness.

Regulations pose constraints for organizations. A regulated or restrictive environment may in some cases be a protected environment, for example when it results in limited competition and the organization is assured of raw materials and markets. A restrictive environment may in other cases be complex. Restrictiveness will in this study be used with particular reference to specific

¹⁾The dimensions static-dynamic and stable-dynamic are used as equivalent. Strictly speaking, stable and dynamic do not refer to the same concept. Stable refers to the degree of decomposition, its opposite is unstable. Dynamic in contrast refers to the degree of motion or movement, its opposite is static. Empirically, however, static and stable tend to occur together.

regulations. It is thus more limited than as used by Khandwalla (1977), who defines restrictiveness in a sense closely related to complexity.

3.4.3 Technology and the production system

There are several ways of defining, conceptualizing and measuring technology. This has led to considerable confusion over what aspects of organizational structure technology may influence and over the importance of technology as a contextual factor.

Technology may be considered as the means or methods and processes that transform or convert input or raw materials into output of desirable goods and services. (Perrow 1970, Woodward 1965). This implies a sequence of physical techniques (operations and equipment) used upon the workflow of the organizations as systems for acquiring, transforming the input and disposing of the output, technology is what is used in the transformation process.

Alternatively technology may be viewed as means-end-relationships or as connections or relationships between actions and their consequences, or outcomes (Thompson 1967). This represents a slightly different way of talking about transformations. Technology in this view is not the activities as much as the conscious and intended use of activities, including those performed by equipment, to accomplish some end.

Thirdly, technology may be defined as the mechanisms or methods used for accomplishing organizational tasks (Perrow 1970). This represents a somewhat more general view of technology.

Whether technology is defined in terms of the transformation process, the relations between actions and consequences or in relation to organizational tasks, it is clear that technology is more than machinery.

The most well-known approaches to technology and typologies of technology are probably those developed by Perrow (1970), Thompson (1967) and Woodward (1965, 1970). Both Woodward and Thompson studied operations technology, which refers to the equipment and interdependence of activities in the workflow. Perrow (1970) studied materials technology, which refers to characteristics of the physical and informational material used.

Thompson (1967) proposed a typology consisting of long-linked, mediating and intensive technology. A long-linked technology involves serial interdependence and manufacturing is typically of the long-linked variety. A mediating technology involves pooled interdependence. Organizations using a mediating technology (including banks, insurance companies) have as their primary functions the linking of customers or clients. The mediating technology requires operating in standardized ways. The intensive technology involves mutual interdependence. It draws upon a variety of techniques in order to achieve a change in some specific object, the selection, combination and order of application being determined by feedback from the object itself. Intensive technology can be found in medical care, in the construction industry, in research and others. The technological interdependencies are important for grouping of activities (Thompson 1967, Gerwin & Christoffer 1974).

Thompson's typology is more general than that developed by Woodward (1965), which is directed towards industrial production. Woodward's typology can be seen to fall within the category of long-linked technology.

Woodward (1965) suggested a scale of production systems ranging from unit production to process production. This is usually summarized in terms of the types of production systems: unit and small batch production, large batch and mass production, and process production. Woodward (1965) thought of technology in terms of technical rationality and argued that as one more from unit production to process production technical complexity increased, predictability of results increased and the chronological age decreased (process production being the most recent

type of production). Technical complexity refers to the amount of machinery used or to the degree of automation, to the smoothness of production or the length of the production run, and to product standardization and predictability. Several technical variables were used to characterize a production system, including the nature of product, production run, type of product and technological changes (Woodward 1965).

The concept of routineness, which is closely related to the degree of programming (Simon 1965 & 1977) is central to Perrow's (1970) development of technology. Since routine tasks are well structured and repetitive, definite procedures for handling them can be worked out. The non-routine tasks are ill-structured and there are no procedures available for handling them. Perrow (1970) suggested that the degree of routineness is influenced by two factors and technology could thus be seen as having two dimensions: variety of stimuli and nature of search process.

By combining the dimensions of technology, four types of technology (Perrow 1970) are obtained: craft, non-routine, engineering and routine. Craft technology involves few stimuli and unanalyzable search and the appropriate organizational structures is decentralized. Non-routine technology occurs when there is a variety of stimuli and search is unanalyzable. Coordination requires feedback. The organizational structure is flexible and polycentralized. Engineering technology is characterized by a variety of stimuli and analyzable search. The appropriate organizational structure is flexible and centralized. In the routine technology there are few stimuli and search is analyzable. Coordination is by planning and the organizational structure is formal and centralized.

Woodward (1965) considers technology at an organizational level of analysis and includes work done by machines. Perrow (1970) considers technology and the work situation and concentrates on work done by people, which implies an individual or group level of analysis. It is therefore necessary to combine several individual measures of technology in order to obtain a measure of technology at the organizational level.

As this study is concerned with the organizational level of analysis Woodward's typology of technology is preferred, although, the variables used for describing technology need to be extended and modified.

The distinctions between technology and product and work flow are not always clear. Woodward (1970) regards the task of production, the products and technology as inseparable. Khandwalla (1977) regards work-flow and technology as inseparable. Workflow refers to the physical organization of the process of transformation, and technology to the mechanical facilities used in the transformation.

Together then Woodward (1965, 1970) and Khandwalla (1977) identify three technical components: products, work-flow and technology or equipment.

The Aston-group (Pugh & Hickson 1976) adopted the following scales of operations technology: automation of equipment, work-flow rigidity, specificity of evaluation of operations and continuity of the units in process. The last scale is similar to the continuity of production as used by Woodward (1965). Thus a fourth technical component may be identified: material flow.

The technical components and variables used for describing technology, or production systems, are listed in Figure 3.1. Technology is defined as a system of activities and techniques that are used in a certain sequence with the purpose of accomplishing a change in a object or producing a product or a service. Work flow, material flow, techniques and products are components of technology. Work flow refers to the sequence of steps or activities necessary for producing a product, and material flow refers to the flow from raw material to finished products. Techniques refer to techniques, tools, equipment, machinery etc that are used in producing product, and products refers to the product-specialization.

Workflow may consist of a fixed sequence of steps or a variable one; the length of the work flow, i.e the number of steps, may vary.

Material flow is expanding when raw materials result in a large number of types of products. When many raw materials are used for producing a small range of products, material flow is condensing. The flow of material may be continuous or consist of whole products. Stock policy refers to whether production is directed towards storage or based on order, i.e. the termination of the material flow.

The *techniques* may imply the use of simple and non-expensive machinery or expensive machinery, requiring considerable investments. The machinery may allow the production of only one type of product or a wide range of products.

The organization may sell only a limited line of *products* or a more extensive line. The products may be standardized or made-to-order. The organization may produce integral or dimensional products.

Technical components	Technical variables
Work flow	sequence length (number of steps) interdependence
Material flow	continuity stock policy expansiveness throughput-time
Techniques	capital intensity automation specialization
Product	dimensional standardization line age

Figure 3.1 Concepts for describing technology

3.5 Summary

In this chapter the study of organizational structure has been reviewed, with particular emphasis on studies within the school of thought known as contingency theory. The fundamental concepts uncertainty and information were examined.

Several limitations of contingency theory were discussed, and it was concluded that contingency theory is primarily a partial theory. Further, it was argued that the situation or context for the operation of computerized information systems is characterized by constrained choice. Hence the limitations of contingency theory can be ignored in the short run with regard to computerized information systems.

Three contextual factors – size, environment and technology – were reviewed. The influence of

two of these — environment and technology — on computerized information systems will be explored later (chapter 7,8). Hence only the conceptualizations and definitions of these factors were examined. It was suggested that environments can be described in terms of four components — customers, suppliers, competitors and regulating groups — and four dimensions — changeability, complexity, hostility and restrictiveness. Similarly it was suggested that technology can be described in terms of four components — work flow, material flow, techniques and product — each with a number of technical variables.

Using available research, the influence of the contextual factors — size, environment and technology — on computerized information systems will be reviewed in the next chapter (chapter 4). It will then be explored on a more detailed level and based on empirical data in later chapters (chapter 7 and 8, appendix). This requires formulating a model for describing computerized information systems (chapter 5).

4. COMPUTERIZED INFORMATION SYSTEMS AND THEIR ORGANIZATIONAL RELATIONSHIPS

It has previously (chapter 1) been argued that computerized information systems constitute a subsystem of the structure of an organization. It was further argued that they are formalized.

The design of computerized information systems has been examined (chapter 2). In this chapter computerized information systems are considered with specific regard to their organizational contexts.

In the beginning of this chapter the research on the consequences of computers is examined. Several pervasive effects of computers and computer systems have been found in this research. However, it is often severely handicapped by a disregard of contextual factors.

Next, some contingency frameworks of information systems are reviewed. They support the belief that contextual factors are relevant with regard to information systems, even though they do not explicitly refer to computerized informations systems.

Finally, three contextual factors — size, environment and technology — are examined and their implications for computerized information systems, discussed.

4. 1 The impact of computers on organizations

During recent years a number of developments have increased the significance of formalized information systems in organizations. Such developments include the emergence of administrative theory and, more recently, the introduction of computers for data and word processing. Many authors believe in a second industrial revolution and some have even predicted the emergence of the information society.

The growing application of computers and computerized information systems stimulated considerable interest in the consequences of this new technology. Perhaps for these reasons, the operations of computerized information systems, and particularly their impact on behaviour in organizations, have become a focus for many research efforts over the past couple of decades.

This work has ranged from surveys of computerization in several organizations (Hoos 1960a & 1960b, Whisler 1970) or surveys of a large number of computer systems (Eason et al 1974), to case studies in a small number of organizations (Bjørn-Andersen et al 1979, Docherty et al 1977, Elizur 1970, Mumford & Banks 1967, Mann & Williams 1960, 1962). Extensive summaries of current research are available (Bjørn-Andersen & Rasmussen 1977 & 1980; Kling 1980).

The impacts on tasks and jobs, including perceived effects on job content, are extensively documented for white collar groups, especially clerks (Bjørn-Andersen et al 1979, Bradley 1981, Docherty et al 1977, Eason et al 1974, Elizur 1970, Mumford & Banks 1967) as well as for blue collar groups (Carlsson et al 1978, Nygaard & Bergo 1975). The effects on centralization have been examined (Hoos 1960a, 1960b, Klatzky 1970, Stymne 1966, Whisler 1970). Potential effects on decision-making in semi-structured decision situations have been explored (Glimell 1975, Hedberg 1970, Keen & Scott Morton 1978, Scott Morton 1971). It has further been argued that computerized information systems have direct implications for industrial democracy (Carlsson et al 1978, Hedberg 1975, Nygaard & Bergo 1975).

The growth of computer applications and computerized information systems at the same time increased the importance of specialists in the design and operation of computerized information systems. This stimulated interest in values of system designers and in user participation in design and administration of computer systems. The orientations of system designers have been explored (Hedberg 1974, Hedberg & Mumford 1975) as well as values and design-approaches (Boguslaw 1965, Mesthene 1970). Issues of user involvement, participation and influence have received attention (DeBrabander & Edström 1977, Høyer 1980, Neergaard 1977, Thurston 1959).

In studies of the effects of computers and computer systems, the variables included in the research models used are limited to computers or computer systems as the independent variable, and effects on tasks, jobs or work organization, as the dependent variables. Correlations are sought between the independent variable and each of the dependent ones. Computers are seen as the central determinants of behaviour. Similarly impacts on tasks and jobs are considered as outcomes of computer systems. Work organization is an outcome of computer systems. The fundamental assumption in the research model is apparently akin to technological determinism, though many of the authors reject this general and fundamental assumption and use the studies to argue for more humanistic and participative approaches to computer system design.

There are numerous inconsistencies in the research results. For example, negative as well as positive effects on job content have been observed and tendencies towards centralization as well as decentralization have been found. These inconsistencies point to a number of limitations which are found to a varying degree in the research models used. Below three limitations to these models are discussed.

First, there are hardly any attempts to differentiate the independent variables in the research model. Computer systems are considered as uniform units having similar characteristics. No distinctions are made between types of computer systems and characteristics of computerized information systems. Impacts on jobs may, however, be dependent on the characteristics of computer systems. Similarly no distinctions are made with regard to computers as part of task technology or as part of control technology.

Second, the impact on organizations or on jobs of other factors than the computer system are mostly disregarded. Mann and Williams (1960) note that they observed the combined effects of reorganization and computerization. Elizur (1970) notes that changes in job content depend less on the computer and more on the way the new tasks have been designed. Others argue that computers allow alternative work organizations (Bjørn-Andersen et al 1979).

The third and most significant limitation is that the studies take no account of contextual factors which may influence both the computer systems and their impacts on organizations and jobs in important ways. Differences in organizational technologies are ignored. Environments of organizations are assumed to be similar.

Hence, when considering the influence of organizational context on computerised information systems, the research on the impact of computers has to date been inadequate, since it fails to take account of the environment of organizations and the consequences of this environment for the development of different types of computer systems.

4.2 Contingency frameworks of information system

Research has identified the existence of systematic relationships between the structure of an organization and its contextual factors. As computerized information systems are part of an organization's structure, it is here suggested that they may similarly be contingent on contextual factors. In this study, computerized information systems are seen as dependent variables. Assuming that computerized information systems are dependent on contextual factors, it is necessary to define both contextual factors and information system variables. Some researchers have recently suggested frameworks of contextual factors and information system variables. A representative list of frameworks is briefly presented in Figure 4.1.

Bjørn-Andersen (1974) argues that the characteristics of man as a decision maker have important implications for computerized information systems. Three models of man as a decision maker are discussed: rational economic man, administrative man and the muddling through model. These models involve different assumptions concerning human information processing. Their implications for computerized information systems are examined. A computerized information system is considered to be composed of four components: collecting, storage, processing and output.

Some researchers have argued that work-unit technology poses critical constraints on the design of an information system (Daft & MacIntosh 1978, MacIntosh & Daft 1978). Based on the dimensions of work-unit technology, task variety and task understanding adopted from Perrow (1970), they found empirical support for the hypothesis that there is a relationship between the technology of a work-unit and the amount and type of information required to perform effectively (Daft & MacIntosh 1978, MacIntosh & Daft 1978). Furthermore, two characteristics of information were assumed to be related to technology: amount of information and information focus. It is proposed further that task understanding is related to information focus and task variety to amount of information. A third information characteristic - information message - emerged from a study of twenty-four work-units. Information message describes whether individuals use information in a quick and decisive manner or whether it is used with careful thought and deliberation (Daft & MacIntosh 1978, MacIntosh 1981, MacIntosh & Daft 1978).

Based on the study of work-units, four patterns of information systems were identified. They are characterized in the following way: An information system is *cursor*y, when small amounts of information are required, information is not precise or detailed but its focus is multiple, and information is used in a quick and decisive way. An information system is *diffuse*, when large amounts of information are required, the focus of information is multiple, and it is typically used in a slow, massaging way. An information system is *concise*, when moderate amounts of information are required, the focus of information is single, and it is used in a quick and decisive way. Finally an information system is *elaborate*, when large amounts of information are required, the focus of information is single, and information is used in a slow and massaging way (Daft & MacIntosh 1978, MacIntosh 1981, MacIntosh & Daft 1978).

The associations between information systems and technologies are as follows: Cursor information systems are associated with technologies that are not well understood and have low variety; diffuse information systems with technologies that are not well understood and have high variety; concise information systems with technologies that are well understood and have low variety; and, finally, elaborate information systems are associated with those technologies that are well understood and have high variety (Daft & MacIntosh 1978, MacIntosh 1981, MacIntosh & Daft 1978).

In spite of the fact that the suggested framework relating information characteristics to work-unit technology (Daft & MacIntosh 1978, MacIntosh & Daft 1978) is particularly relevant to human information processing, it supports the general idea that technology has significant implications for the characteristics of information systems.

Three other frameworks (Figure 4.1) are particularly oriented towards accounting information

Authors(s)	Contextual factors	Information system variables
Bjørn-Andersen 1974	rational economic man administrative man muddling through model	collecting storage processing output
Daft & Mac Intosh 1978 Mac Intosh 1981 Mac Intosh & Daft 1978 Ginzberg 1980	work-unit technology environment technology formal organization informal organization	information amount information focus (ambiguity) information message (use) decisional — procedural independent — interdependent
Gordon & Miller 1976	environment organization decision-making style	information load centralization of reporting cost allocation methods frequency of reporting method of reporting time element of information performance evaluation measurement of event valuation methods
Waterhouse & Triessen 1978 Whisler 1975	technology environment uncertainty repetitiveness volume	planning and resource allocation performance measures common — uncommon intensity of use decision-making — information processing application substitution - complement

Figure 4.1 Some Contingency Frameworks of Information Systems

systems or management accounting systems (Ginzberg 1980, Gordon & Miller 1976, Waterhouse & Tiessen 1978). They all argue that information systems are contingent on environment and technology.

Ginzberg (1980) identifies two pairs of information system variables. First a distinction is made between decisional and procedural orientation, decisional information systems serve to support managers' decision making processes, while procedural information systems serve to implement established organizational procedures. Second a distinction is made between information systems that support independent tasks and those that support interdependent tasks, the former attempts to localize information while the latter facilitates information flow and sharing.

By combining the two dichotomized information system variables Ginzberg (1980) obtains four archetypes of information systems:

- procedural - independent
- procedural - interdependent
- decisional - independent
- decisional - interdependent

Ginzberg (1980) further considers four contextual factors and a number of characteristics for each factor. An important characteristic of environment is environmental stability. Technology is characterized with regard to routineness (Perrow 1970). The characteristics of formal organization are bureaucracy, centralization, differentiation and integration. Finally the characteristics of informal organization are norms and power distribution.

Ginzberg (1980) suggests that the interaction of contextual and information system variables determines the organizational fit of an information system. An assessment is made of the degree of fit that exists between each of the contextual variables and each of the information system variables.

Gordon and Miller (1976) propose no less than eight information system variables. Some of these are exclusively oriented towards accounting, the rest will be presented in the next chapter (section 5.2.3). Three contextual factors, each having some dimensions, are suggested. The environment, including a technological component, of an organization is characterized by at least three key dimensions: dynamism, heterogeneity and hostility. There are five characteristics of organization: decentralization, differentiation, integration, bureaucratization and resources. Finally, decision making style has six characteristics: analysis, time horizons, multiplexity, adaptiveness, proactivity and explicitness of objectives. Gordon and Miller (1976) argue that environmental, organizational and decision style traits are not distributed randomly but tend to cluster together to form commonly occurring configurations. Three archetypal firms are identified: adaptive, running blind and stagnant bureaucracy. The main information system characteristics which are hypothesized to be effective for each archetypal firm are identified.

Waterhouse and Tiessen (1978) develop a model for the comparative analysis of organizations which permits the identification of possible control requirements of various organizational types. They suggest that the structure of an organization is largely dependent on its context and that alternative structures create a need for different control mechanisms. Two contextual factors are identified: technology and environment. They are specifically concerned with how management accounting processes — such as planning and resource allocation, and performance measures — are affected.

Whisler (1975) argues that uncertainty, repetitiveness and volume have significant influence on the use of computers and computer systems. It seems reasonable that highly repetitive decisions are the ones most likely to justify the use of computers. Furthermore, computer use is most likely to be justifiable where a high volume of information must be processed.

The three factors uncertainty, repetitiveness and volume are dichotomized and combined into

eight different conditions. Organizational use of computers is considered under these conditions. First, computer use in organizations will be most common and most intensive in conditions of high volume and high repetitiveness. Second, decision making applications will be most common in conditions of high repetitiveness, and information processing applications will be most common in conditions of high volume. Third, substitution effects will be strongest in conditions of high volume combined with either high repetitiveness or high certainty. Complementation effects will be strongest in conditions of both high uncertainty and high repetitiveness.

In summary it can be noted that the contingency frameworks of information systems reviewed support and further elaborate the idea that information systems are contingent upon contextual factors. The frameworks are firmly grounded in available research on the contingent character of organizational structure, and hence they have extensive theoretical support. Empirical support is, however, lacking, with one or two exceptions (e.g. Daft & MacIntosh 1978, MacIntosh & Daft 1978). The contextual factors identified in most frameworks are environment and technology although a number of other contextual variables have been suggested.

Furthermore, only Bjørn-Andersen (1974) and Whisler (1975) propose frameworks which are specifically oriented towards computers and computerized information systems. One of the other frameworks reviewed is particularly concerned with human information processing (Daft & MacIntosh 1978, MacIntosh 1980, MacIntosh & Daft 1978). In designing computerized information systems it is, however, important to take into account the requirements of human information processing as is suggested in the work of Bjørn-Andersen (1974).

The remaining analyses are not addressed towards computerized or formalized information systems, but to information systems in general or accounting systems in particular (Ginzberg 1980), Gordon & Miller 1976, Waterhouse & Tiessen 1978).

None of the frameworks described here are regarded as especially relevant for explaining the characteristics of computerized information systems in production and manufacturing (specifically processes for acquiring, converting and exporting materials and products). As these information systems are the focus of the present study, an alternative model for describing computerized information systems is developed (chapter 5). In developing this model, relevant parts of the frameworks reviewed are used.

4.3. Three contextual factors

In general, investigations of the relationships between organizational structures and contextual factors have led to the suggestion that the characteristics of an organization's computerized information systems may be similarly contingent upon contextual factors. This suggestion is supported by the contingency frameworks of information systems reviewed in the previous section. In these frameworks three contextual factors, or classes of determinants or correlates of organizational structures, are considered specifically important. These factors have been examined previously (chapter 3): the size of an organization, the environments in which it operates and its technology. Their implications for computerized information systems will briefly be considered in this section based on available research results.

4.3.1. Implications of size

It has previously (section 3.4.1) been argued that the relationships between size and organizational structure are relatively complex. Further, size has generally been assessed in relation to the total organization, or occasionally, to the individual plant. It seems likely that size interpreted in this way will influence higher levels more than lower levels. When considering computerized information systems used at the lower levels of an organization it is difficult to identify the influence of size upon the nature of the computerized information system. At the lower levels of an organization, it seems likely that technology will have a more significant impact.

With regard to the relationship between computerized information systems and organizational size there seem to be two points of interest. First, there is a greater tendency among large organizations to use computers than there is among small organizations. Second, computers are used for clerical routines by most organizations, still computers are used for control routines by a greater percentage of large organizations than of small organizations.

This is further supported by the findings from two studies undertaken in the engineering industry and in mining and manufacturing in Sweden, respectively during the early 1970:s (ADB och Arbetskraften 1973, 1975). In both industries, it was found that only a few firms with more than 500 employees did not use any computerized routines, i.e. did not have access to a computer. Computerized routines were divided into three groups: clerical routines, control routines and technical routines (i.e. technical computations, OR-models, simulation, numerical control etc). It was found that only a few companies did not use some clerical routine. In engineering industry, it was found that the use of control routines and technical routines increased considerably with increases in company size (ADB och Arbetskraften 1973, 1975).

There seem to be a number of explanations for these findings. A simple explanation considers formalization as the mediating factor between computer use and organizational size. As organizations grow in size there is normally an increased degree of formalization (Pugh & Hickson 1976). Further it has been argued previously (chapter 1) that computerized information systems presume formalization.

Other and more significant explanations refer to the fact that experience suggests that large organizations make more use of formalized information and control systems at higher levels (Child 1977). First, large organizations have economies of scale and increases in organizational size normally mean greater financial resources. This facilitates investment in computers, computerized information systems and further specialist resources for developing and maintaining computerized information systems. However, such a relationship seems to decrease in importance as the size and price of computers decrease.

A second and more complex explanation refers to managerial perception of control loss (Williamson 1970). An increasing number of levels in an organization implies a control loss, in so far as transmitting information is characterized by cumulative losses. Such an effect may be experienced in contexts in which the influence of person-to-person contact becomes small. It seems likely that a belief in the existence of such a source of control loss will tend to encourage the introduction of information systems having characteristics considered likely to offset this effect (Banbury & Nahapiet 1979, Nahapiet & Bandbury 1974).

4.3.2 Implications of environment

Several researchers have emphasized that the nature of the environment is an important contextual factor which is likely to influence the characteristics of an organization's computerized information systems (e.g. Ginzberg 1980, Gordon & Miller 1976, Waterhouse & Tiessen 1978). In the previous chapter, the particular characteristics which are likely to be especially important were identified as being: changeability, complexity, hostility and restrictiveness.

It seems likely that there will be a greater tendency to use computers in organizations operating in environments characterized as benevolent, constant and simple. The logic is that the degree of formalization may increase as environments become less changing, less complex and less hostile. The relation between computerization and formalization has already been noted (chapter 1)

With regard to the relationships between characteristics of computerized information systems and environmental influences the arguments are relatively complex. Very briefly, if environments are characterized by relatively higher degrees of hostility, changeability or complexity, organizations operating in these environments will need to monitor the environment more closely, to become more adaptive and to reduce slack. It seems probable that these organizational requirements will

tend to encourage the introduction of computerized information systems having characteristics likely to support the organization in satisfying these requirements (Gordon & Miller 1976).

4.3.3 Implications of technology

The last contextual factor to be examined with regard to its implications for computerized information systems is the technology (or technologies) an organization utilizes. In this case the arguments are complicated by the existence of a number of different definitions of technology.

Technology may be conceptualized with regard to the work-unit. It is then argued that an organization is not characterized by a single technology but by a number of technologies. The technologies are characterized in terms of task knowledge and task variety (Perrow 1970). Relationships have been observed between work-unit technology defined in these terms and information system characteristics (MacIntosh 1980).

Alternatively, technology may be considered at an organizational level of analysis, usually in relation to the core technology of an organization. The typology encompassing unit, small batch, large batch, mass and process production technologies (Woodward 1965) is well-known in this respect. The implications of this perspective for first, the tendency to use computers, and second, the nature of computerized information systems are examined below.

First, there is an increased tendency among organizations to use computers as they move from unit to process production technology. The logic behind this argument refers to the increased possibilities to routinize implied by a movement from unit to process production technology, and hence to an increased degree of formalization.

In a study of engineering industry the companies were grouped into five categories: (1) not technically complex unit or small batch production, (2) technically complex unit or small batch production, (3) large batch production, (4) mass production, and (5) mixed production. Among companies employing less than 500, it was found that groups 3 and 4 had the greatest percentage of computer users and group 1 the smallest percentage (ADB och Arbetskraften 1973).

In another study of mining and manufacturing the companies were grouped into (1) small batch, (2) large batch, (3) mass and (4) process production. It was found that the tendency to use computers was greater in process production than in small batch, large batch and mass production. This was particularly evident among companies employing less than 500. Further, concerning stock policy, it was found that the tendency to use computers was greater among companies manufacturing for stock than among those manufacturing on customer orders (ADB och Arbetskraften 1975).

Second, the characteristics of computerized information systems will change when moving from unit to process production technology. Unit production requires a computerized information system that supports flexibility and is loosely operated. Large batch production and particularly mass production require computerized information systems that are tightly operated and support productivity, efficient production and high utilization of production equipment. The argument can be extended to process production if computers in process control are included.

Computerized information systems can be grouped into clerical routines, control routines and technical routines. In the study of engineering industry referred to above, it was found that a greater percentage of companies in groups 5, 2 and 3 used control routines than in groups 1 and 4. Technical routines were only used in groups 2, 5 and 3 (ADB och Arbetskraften 1973). In the study of mining and manufacturing, also referred to above, four groups of companies were distinguished. The percentage of companies using control routines varied only slightly between the groups. The percentage of companies using technical routines was very small but increased slightly towards process production.

4.4 Conclusions

In this chapter current research on computers and information systems in organizations has been examined. It has been argued that the study of computerized information systems could benefit from a consideration of contextual factors. The main points in the chapter are summarized below.

First, research on the effects of computers was briefly reviewed and a number of deficiencies and inconsistencies were found. It was suggested that a consideration of contextual factors could have resolved these inconsistencies and deficiencies.

Second, a number of contingency frameworks of information systems were reviewed. They were, however, found insufficient for the research undertaken here as they were not directed towards information systems for production and manufacturing. Further, they mostly did not consider computerized information systems.

Finally, the implications of the three contextual factors (size, environment and technology) for computerized information systems were explored. Significant relationships were hypothesized and supported by available empirical data.

In order to be able to formulate more specific and detailed hypotheses on the relations between contextual factors and the characteristics of computerized information systems it is necessary to develop a more suitable model of computerized information systems. Such a model can then be used in formulating hypotheses based on empirical data (chapter 8).

5. CHARACTERISTICS OF COMPUTERIZED INFORMATION SYSTEMS

This chapter reviews a number of models of computerized information systems and finally proposes a model for describing and classifying information systems. There are two criteria that such a model must satisfy: first it must be possible to generalize descriptions, and second it must be possible to relate the properties of the model to the dimensions of uncertainty as well as of the contextual factors.

There are several ways of describing and classifying computerized information systems, some of these are traditional, that is oriented towards company functions, others are oriented towards the range of performances offered by a computerized information system. For the purposes of the present study the models of computerized information systems are considered to consist of two subsets: content-oriented and generic models. The *content-oriented models* are directed towards the application-areas of computerized information systems, or the kind of data a computerized information system collects. The *generic models* are directed towards classes of structural or functional attributes of computerized information systems.

The emphasis in this study is on generic attributes of computerized information systems. Accordingly the content of a computerized information system is defined in very simplistic terms only.

5.1 Content-oriented models

The content-oriented models are directed towards the application or subject-area of a computerized information system, and hence to the kind of data collected. Traditional models for classifying computerized information systems are often based on application areas.

One common model for classifying computerized information systems refers to types of application (ADB och Arbetskraften 1973, Eason et al 1974): clerical routines, control routines and technical routines. The largest category is *clerical routines*, which perform the basic information processing tasks. Their main purpose is record-keeping, they keep track of events; the tasks they perform are many: receiving and processing orders, recording stock-levels, personnel records, invoicing customers, and maintaining accounts etc. Clerical routines usually involve simple processing and high volumes of stored data.

Control routines are designed to go beyond the mere record-keeping and storing of information to either taking or proposing action on the bases of information. Their primary purpose is to assist users in operational control decisions. Control routines normally contain decision rules and

complex algorithms for functions such as stock re-ordering levels, stock re-ordering quantities, resource allocation etc.

The smallest category is *technical routines*, which covers a broad range of sophisticated systems and computations. They include simulations, engineering computations, programming NC-equipment etc.

The indication of the content of a computer system is very limited when computer systems are classified according to type of application. The major distinction between the three categories appear to be the degree of sophistication of processing or the use of models for processing.

In order to be able to relate descriptions of computerized information systems to contextual factors some indication of the content of a computerized information system is necessary. This may be obtained by looking at the subject area of a computerized information system.

Computerized information systems can be classified in terms of subject area, i.e. according to the kind of data they collect. Computer systems can very crudely be classified according to the kinds of data collected, e.g. financial, production or administrative data. Financial information systems include accounting, budgeting etc. Production information systems include stock-holding, order-entry etc. Administrative information systems include personnel, payroll etc. Finally each of these categories may be sub-classified. However, a classification according to kind of collected data does not discriminate between computer systems that are and those that are not influenced by contextual factors.

The present study concerns only computerized information systems collecting production data. Hence, computerized information systems need to be sub-classified according to type of production data. Further, on this level it is possible to group computerized information systems into core- and boundary-system.

Production data can be sub-classified by considering the production system and its associated information systems. The production system of an organization, including certain supporting functions, may be considered as a flow of activities for receiving materials, converting them and exporting products. It is further possible to identify an associated and parallel sequence of information systems for purchasing, manufacturing, stockholding, order-entry, order-statistics, invoicing and sales statistics.

Thompson (1967) makes a distinction between technical core activities and boundary spanning activities. Technical core refers to production in a restricted sense, the actual conversion of materials into products, and the means used in this process. Organizations seek to protect their core technologies from environmental influence. Boundary activities are particularly important in the exchange-relations between an organization and its environment. The crucial problem for the boundary activities of an organization is adjustment to environmental influences.

Similarly, in order to reflect differences in environmental influence, computerized information systems may be grouped into core- and boundary-systems. Core-systems support activities in the technical core, and boundary-systems support boundary-activities. It may be assumed that boundary-systems are more influenced by the environment of an organization than are core-systems.

The core-systems include computerized information systems for manufacturing and stock-holding. Boundary-systems are concerned with information flows across the boundary of an organization, they may further be divided into input- and output-systems. Input-systems support input-activities, they consist primarily of computerized information systems for purchasing. Output-systems support output-activities, they consist of order-entry, invoicing, order-statistics and sales-statistics.

The content-oriented model that will be used in this study consists of the detailed classification of production data and the grouping into input-, core- and boundary-systems.

However, the content-oriented models do not discriminate between computerized information systems in different organizations. For example, a computer system for invoicing does not have the same characteristics in every company. In order to discriminate between computer systems, which have similar contents, it is necessary to consider generic models.

5.2 Generic models of computerized information systems

The generic models are directed towards classes of structural or functional properties. The generic models presented here are divided into three separate groups: components of computerized information systems, coupling of users and computerized information systems, and finally, properties of a computerized information system. Among these three groups, components are the most general and properties the most specific.

5.2.1 Components of a computerized information system

Some researchers have suggested components of computerized information systems. A representative list of componenets is given in Figure 5.1.

Nahapiet and Banbury (1974) identify three components. The primary function of the data processing system is to collect, select, store, process and distribute data and information. The model represents the decision situation and associated decision processes. It refers to both the methods of analysing decision situations and to data and information to be used in the associated decision process. Hence, the model specifies what data are to be collected, the manipulations to be carried out on them, to whom information generated is to be communicated and the criteria to be used in choosing between alternatives. The interface refers to the link between users and the system during both its design and operational phases. The link consists not only of the actual coupling between the computer system and the user but refers also to the involvement and participation of users in design and their ability to bring about changes in the system once it is implemented.

Nahapiet & Banbury 1974	data processing system model interface
Bjørn-Andersen 1974	data collection storage processing output
Losty 1971	data base information elements decision models

Figure 5.1 Components of Computerized Information Systems

The components suggested by Bjørn-Andersen (1974) and Losty (1971) are more narrow and can largely be seen as components of the data processing system identified by Nahapiet and Banbury (1974).

Losty (1971) suggests three components. The data base refers to all the information, internal and external, stored. Decision models refer to the manipulations carried out on data and the rules for processing information. Information elements are the inputs and outputs of a computerized information system with particular emphasis on reports produced.

Bjørn-Andersen (1974) suggests four components. Data collection involves the methods and speeds of capturing and recording data. Output involves the method and speed of presenting information, and the design of reports. Processing refers to the manipulation of information, the use of decision models and programming languages. Storage involves how much data is stored, by what method, and in what kind of storage-unit.

Information systems assist in collecting, storing, processing and presenting information about an organization and its environment. The components (Figure 5.1) suggested obviously each corresponds to one or more of these system-functions. The components suggested by Bjørn-Andersen (1974) correspond directly to the functions, while among the components suggested by Losty (1971) information elements seem to include collecting as well as presenting information. The components suggested by Nahapiet and Banbury (1974) are more comprehensive. The data processing component includes all the components suggested by Bjørn-Andersen (1974) and by Losty (1971); further the interface component refers to a computerized information system during design as well as during operation. The interface during design concerns the computerized information system at a meta-level, while the interface during operation concerns the actual computerized information system.

The components, corresponding to functions of a computerized information system, provide a framework for organizing other generic properties of a computerized information system during operation.

5.2.2 Coupling of users and computerized information systems

Some researchers address themselves to the coupling of users and computerized information systems. They are listed in Figure 5.2. They may be divided into two groups. One group is concerned with the coupling between the computerized information system and the user or decision maker (Damodaran et al 1974, Eason et al 1975, Losty 1971). A second group is concerned with the relation between the computerized information system and the decision process (Alter 1977, Edström 1973, Mason 1975).

Damodaran et al (1974) argue that there are three kinds of coupling: dominant, active and passive. Losty (1971) only considers active and passive, although his use of the terms corresponds to that of Damodaran et al (1974).

In the dominant coupling, the interaction with the computerized information system is limited to a set of procedures for data input. The computer thus dominates and controls the work of the employees concerned. In the active coupling users are supplied with outputs containing pre-specified information at established intervals. Active systems process and present information at established intervals. Active systems process and present information without any action on the part of the user once the system is implemented. The computer constrains the work of the employees. In the passive coupling information is produced only at the request of the user. Users are allowed to specify the output, the kind and extent of information processing.

Eason et al (1975) identify three modes of using or interacting with a computer system. In the input mode the user is primarily concerned with entering data into the computer system. The

Damodaran, Stewart & Eason 1974	dominant active passive
Eason, Damodaran & Stewart 1975	input-mode output-mode instruction-mode
Losty 1971	active passive
Alter 1977	file drawer system data analysis system analysis information system accounting models representational models optimization models suggestion models
Edström 1973	data support analysis support evaluation support initiation support
Mason 1975	databank predictive information system decision-making information system decision-taking information system feedback information system systemic information system

Figure 5.2 Coupling of users and computerized information systems

user receives outputs automatically or on request in the output mode. Only in the instructional mode can the user manipulate and change the data stored. The input mode allows the user the most restricted access to a computer system.

The mode of interaction and the kinds of coupling are interrelated. Dominant couplings appear to be characterized exclusively by the input mode. In the active and passive couplings the output and instruction modes seem to increase in importance. In distinguishing between active and passive systems an important factor is whether reports are fixed and pre-defined or variable.

The remaining three researchers address the relationship between the computerized information system and the decision process.

Mason (1975) argues that there are several points of articulation between the information system and the decision making process. Decisions are seen to consist of a sequence of activities or components starting with a source and ending with the actual taking of a decision. There are five components: a source component, a data component, a component for prediction and inference, a component for value and choice, and finally an action component.

At first, four fundamental classes of information systems are identified: databank, predictive information system, decision-making information system and decision-taking information system (Mason 1975). The four classes are more and more inclusive, i.e. a predictive information system includes a databank etc. The databank merely observes, classifies and stores any data item which may be potentially useful, and it contains only the source- and data-components. A predictive information system includes the drawing of inferences, and "what-if"-questions are allowed. A decision-making information system requires an optimizing model supported by predictive systems and databanks. Finally a decision-taking information system encompasses all the components in a decision and thus requires that management's values and fundamental assumptions be included. Computerized decision-making system and decision-taking systems are still rare, and likely to remain so, except in certain restricted areas not requiring human judgment. Process control is an example of a decision taking system.

Two further classes of information systems are proposed by Mason (1975). These are the feedback information system and the systemic information system. Feedback (or cybernetic) system can be formed through combinations of the four fundamental classes of information systems. The purpose of a feedback information system is to maintain the system on course. The purpose of systemic information systems is to expose assumptions so that they may be examined and reconsidered. All information systems contain assumptions and each class of information systems has different kinds of assumptions incorporated. Hence, consideration of each of the previous classes of information systems suggests the need to examine assumptions carefully.

Edström (1973) argues that information systems are used to support sub-functions in the decision process. The sub-functions identified are: data collection, problem identification, problem solving, evaluation, and adaptation and learning. Information support can be given in terms of data, initiation, analysis and evaluation, or possibly some combination. For example, analysis and evaluation support are often combined in a decision model. The four types of information support are not inclusive, i.e. data-support refers to the data collection sub-function only, initiation support to the problem-identification sub-function only etc.

Alter (1977) argues that the characteristic which distinguishes between types of decision support systems is the degree of action implied in decision output (i.e. the degree to which the system's output could directly determine the decision). This is related to a set of operations extending from simple extremely data oriented to extremely model oriented operations. The idea is that a decision support system can be categorized in terms of the generic operations it performs, independent of the type of problem, functional area, decision perspective etc.

Based on a comparative study of a sample of 56 decision support systems, Alter (1977) proposes

seven types of computerized information systems, three of which are data oriented and four are model oriented. The data oriented computerized information systems are file drawer systems, data analysis systems and analysis information systems; these allow access to data and provide means for simple manipulations of data. The model oriented computerized information systems are accounting models, representation models, optimization models and suggestion models. These calculate consequences of actions or provide guidelines for actions. One implication of the proposed typology is that there are many different ways to use computers in supporting decision-making.

Alter (1977) did not find any significant difference between interactive and batch processing decision support systems, since an optimization model might require two or more hours of preparation, setup and run-time. Examples of decision-support systems given by Alter (1977) include terminal-oriented or on-line computer systems as well as batch processing systems. Interestingly, speed of communication is not considered a major characteristic of decision support systems, contrary to other findings (Hedberg 1970, Scott Morton 1971).

Information support (Edström 1973) is similar to decision support (Alter 1977). Both apparently assume that there are different levels of articulation between a computerized information system and a decision process. Decision support systems, as the term is used by Edström (1973) and Alter (1977), may be distinguished by the phase of the decision process to be supported and the operation to be performed. The operations imply a wide spectrum from simple operations to the use of decision models.

Decision support systems may further be distinguished from other types of computer systems, which may be called EDP-systems (Alter 1977). EDP-systems are usually designed to automate and expedite transaction processing, record-keeping and business reporting. EDP-systems usually use only a limited set of operations.

5.2.3 Properties of information systems

A number of researchers have suggested properties of information systems, to some extent relating them specifically to computerized information systems. They are listed in Figure 5.3. The models are reviewed below. The properties presented are also designated as policy variables (Carroll 1967, Galbraith 1973), design parameters (Gordon et al 1978) or dimensions (Swanson 1978).

Carroll (1967) and Galbraith (1973) suggest that information systems can be differentiated on four properties: timing, scope, formality and decision mechanisms.

Timing refers to the length of time between decisions, or the frequency of processing information. It may be dichotomized into periodic and continuous information flow. Information flow is periodic, when information is transmitted at fixed intervals, e.g. a job shop schedule issued once every two weeks. On the other hand, information flow is continuous when information is continuously communicated, e.g. continuous updating of seat-reservations, or constant surveillance of operations in a process-control system.

The second property is the scope of the data base available to the decision mechanism. Scope may be dichotomized into local and global data base. If the decision mechanism (man/men, machine/machines, man-machine systems) has access to information only about the situation in its immediate location, the data base is local. If the decision mechanism on the other hand is provided with information on the status of all system entities regardless of their location, the data base is global.

By dichotomizing and combining timing and scope four types of information systems are obtained (Carroll 1967, Galbraith 1973):

Carroll 1967 Galbraith 1973	timing scope of the data base degree of formalization capacity of decision mechanisms
Ginzberg 1980	decisional - procedural independence - interdependence
Gordon, Larcker & Tuggle 1978	content format form focus orientation time horizon frequency
Gordon & Miller 1976	method of reporting information load external - internal time element frequency of reporting degree of centralization
Rørsted 1963	integration
Swanson 1978	inner- or other-directed internally or externally based self- or other-referencing

Figure 5.3 Properties of Information Systems

- local-periodic
- local-continuous (or local real-time)
- global-periodic
- global-continuous (or on-line real-time)

The local periodic information systems involve scanning information in the immediate location of the decision mechanism at stated intervals. Interdependence is often ignored. In the local real-time information system, information may be scanned continuously and decisions are made when required by the conditions. The global periodic information system involves scanning at fixed intervals the status of interdependent system entities. A batch processing computerized system is typically a global periodic information system. In the on-line real-time information system, information may be communicated continuously and comes from several, even remote, system entities.

The degree of formality or formalization is a third property of information systems. Formalization refers to rules and categories for classifying and communicating information. It creates a language with which members of the organization can communicate about events that the organization faces. Not all information can be formalized. Formalization can effectively handle only the type of uncertainty in which known factors may acquire unknown values. If the factors are unknown, the activities or events are ambiguous, and judgement rather than quantitative measures is required. In this context formalization is difficult.

The last property refers to the capacity of decision mechanisms to process information. There are two major thrusts for increasing the capacity of information processing. One involves group decision making and the second involves using computers.

The properties suggested by Gordon et al (1978) parallel those suggested by Gordon and Miller (1976). Collectively Gordon et al (1978) refer to the seven properties (see Figure 5.3) as the information characteristic. The definitions of the corresponding properties suggested by Gordon and Miller (1976) are either unclear or implicit. In addition to the properties which correspond to the information characteristic, Gordon and Miller (1976) suggest attributes which are particularly relevant to accounting information systems. These accounting properties include allocation methods, financial versus non-financial value, historical cost versus market value.

Content (Gordon et al 1978) refers to the kind of information included in the information system. Format (Gordon et al 1978) and method of reporting (Gordon & Miller 1976) refer to how information is presented, for example graphs, tables, diagrams, verbal etc. Form (Gordon et al 1978) of the data items involves specifying whether data items are to be quantitative or non-quantitative. Focus (Gordon et al 1978) touches the issue of whether the data items are to be broad and diffuse or whether they are to be rather specific and narrow. A parallel concept is that of information load (Gordon & Miller 1976) which depends on the breadth and depth or degree of detail of information. Orientation (Gordon et al 1978) and the pair external and internal (Gordon & Miller 1976) refer to whether facts with an internal or an external genesis are reported. Time horizon (Gordon et al 1978) and time element (Gordon & Miller 1976) concern whether data items are ex post (what has happened) or ex ante (what is forecasted or planned to happen). Frequency (Gordon et al 1978) and frequency of reporting (Gordon & Miller 1976) are similar to the timing-dimension suggested by Carroll (1967) and Galbraith (1973). In addition, Gordon and Miller (1976) suggest degree of decentralization, i.e. whether organizational sub-systems or units have separate information systems.

Swanson (1978) suggests three properties, collectively referred to as the locus of information (see Figure 5.3). Information is inner-directed when it is used to influence the organization itself, it is other-directed when it is used to influence other organizations. Advertising is typically other-directed. Information is internally based when it is produced internal to the organization, it is externally based when it is produced external to the organization. Information is self-referencing when it refers to the organization itself, it is other-referencing when it refers to other than the organization itself.

Røstved (1963) introduces the concept of integration. Computerized information systems are integrated if data are used by several systems, for example data may be used concurrently in several systems from a common database or data from one system may be used in the next system.

Integrated data-processing is defined as a design-principle, which applied to its ultimate consequence leads to a situation in which: (1) each input data item is recorded only once, (2) each desired output data item, produced from one or several of the input data items, is produced only once, and (3) all output data items are produced using as simple processing as possible.

Røstved (1963) argues that it is necessary to delimit the data processing system in order to prevent the system from growing uncontrollably. There are three methods to achieve this: delimiting with regard to input, with regard to output, and with regard to files. Delimiting with regard to input means restricting the system to a given set of input and those outputs that are completely or partially produced from the set of inputs. Delimiting with regard to output implies restricting the system to a given set of output and those inputs necessary for producing the set of outputs. Finally delimiting with regard to files means restricting the system to a set of files, the necessary inputs and the outputs produced. The relations between input and output information sets are important when delimiting data processing systems.

Finally there are the properties suggested by Ginzberg (1980). An information system is procedurally oriented if it serves primarily to implement established organizational procedures. It is decisionally oriented if it is designed specifically to support decision making in semi-structured decision situations. However, Ginzberg recognizes that procedural and decisional do not have to be alternative types of information systems but may be different roles fulfilled by a single information system. An information system attempts to support independent tasks when the information required for task completion is localized. An information system attempts to support interdependent tasks when communicating, sharing and coordinating information is facilitated. The dimension independent - interdependent closely resembles the concept of scope (Carroll 1967, Galbraith 1973).

Figure 5.3 lists a number of information system properties, though a few of these have been suggested more than once. The list includes timing or frequency (Carroll 1967, Galbraith 1973, Gordon et al 1978, Gordon & Miller 1976), orientation (Gordon et al 1978, Gordon & Miller 1976, Swanson 1978), scope or interdependence (Carroll 1967, Galbraith 1973, Ginzberg 1980). These properties are examined below.

The property referred to as timing can be split first into frequency and speed of communication. Frequency of communication refers to how often information is communicated while speed of communication refers to how quickly information is communicated. Secondly, timing may be subdivided into collecting and reporting information, giving:

- frequency of collecting
- frequency of reporting
- speed of collecting
- speed of reporting

Considering system orientation, the usage of the concepts external and internal may refer to at least four factors: the source of information, the owner of information, the receiver of information and the reference of information.

The source of information refers to the position where information is generated or produced. Swanson (1978) uses the concepts internally and externally based, while Gordon et al (1978) use orientation. The owner of information refers to where information is available and this aspect is often used in a way that coincides with source. The receiver of information describes whoever receives or is influenced by the information (cf the distinction between external and internal accounting). Swanson (1978) uses the concepts inner- and other-directed.

The reference of information is the event described by some communication. This event may belong to processes within the organization, to processes in the environment or to exchange processes (Emery & Trist 1965): Often only two categories of information reference are allowed. Swanson (1978) uses the concepts of self- and other-referencing.

The properties of computerized information systems (Figure 5.3) which have been discussed above can be seen to refer to different components (Figure 5.1). However, they all refer to the data processing system (Nahapiet & Banbury 1974) and some to the interface, particularly the operational link.

The properties proposed by Gordon et al (1978) and Gordon and Miller (1976) refer to a large extent to the output component or information element-component. Others, suggested by Carroll (1967), Galbraith (1973), Ginzberg (1980), Rørsted (1963) and Swanson (1978) refer mainly to the storage or data base component. In later sections it is attempted to integrate these concepts into a coherent framework.

5.2.4 Conclusion

There are several difficulties with the generic aspects of information systems discussed. Specifically, they refer to different kinds of problems. For example, some deal only with computerized information systems while others are concerned with information systems in general; some concentrate on accounting systems while others have no such restricted focus. However, when considering computerized information systems, some of the aspects identified are not relevant. These include formalization (Carroll 1967, Galbraith, 1973) since computerized information systems presume formalization and decision mechanism (Carroll 1967 and Galbraith 1973) since computerized information systems refer to the machine component of a decision mechanism. Hence the various aspects or characteristics belong to different frames of reference.

The relations between components, coupling and properties are unclear as researchers have addressed themselves almost exclusively to aspects within a single group of generic properties. However, for example some aspects timing and internal - external cover a number of distinct sub-aspects.

It is, however, most significant that the majority of generic properties have not in any major way taken contextual factors into account. Each model reviewed covers only a limited number of properties. The models described are, therefore, insufficient for the purpose of developing a contingency framework for computerized information systems which relates characteristics of computerized information systems to the contextual factors environment and technology.

5.3 Proposed model of generic characteristics

This chapter began by proposing two criteria that a model for describing computerized information systems must satisfy. It must be possible to generalize the properties and to relate them to the dimensions of uncertainty and of contextual factors.

A number of content-oriented and generic models of computerized information systems have been reviewed. The content-oriented models fail to a large extent to fulfill the criteria proposed. The generic models are specifically lacking with respect to the criterion of relating characteristics to the dimensions of contextual factors.

The model developed here for describing computerized information systems contains generic rather than content-oriented characteristics. The generic properties make it possible to compare computerized information systems, accordingly they are generalizable. Furthermore the model is aimed at relating characteristics of computerized information systems to dimensions of uncertain-

ty and contextual factors. This is done by identifying two dimensions, complexity and time-orientation, of computerized information systems that correspond with the dimensions of uncertainty. In developing the model, the generic models previously reviewed will be used. Accordingly it will be necessary to take account of overlaps among the generic models, the relations between components, coupling and properties, and the lack of distinction between subspects of properties.

Information can be regarded as reducing uncertainty (Ackoff 1958, Duncan 1972, Galbraith 1973; cf section 3.2). Thus information systems are means for coping with uncertainty. Information systems, therefore, assist users or decision-makers in collecting, storing, processing and presenting information about an organization and its environment. Uncertainty and the functions of an information system are fundamental to the development of a model of a computerized information system.

The model proposed is shown in Figure 5.4. Here the characteristics of computerized information systems are classified first, in terms of data base, reports and processing, and second in terms of time orientation and complexity. Time orientation and complexity refer to dimensions of uncertainty while data base, reports and processing refer to the functions of an information system. Data base, reports and processing also correspond to the components of a computerized information system (Bjørn-Andersen 1974, Losty 1971) described previously (Figure 5.1).

In order to perform the functions of collecting, storing, processing and presenting information, a computerized information system can be seen to have characteristics that refer to these functions. The characteristics of a computerized information system are classified in terms of data base, reports and processing. Characteristics referring to a data base are related to collecting and storing data, while characteristics referring to reports are related to presenting data to a user. Finally, characteristics referring to processing concern the means for processing data.

Two dimensions of uncertainty have been identified (section 3.2): the degree of complexity and the degree of dynamism.

In order to relate the characteristics of a computerized information system to the complexity and dynamism of uncertainty they are classified according to the complexity or time-orientation of a computerized information system. First, it is hypothesized that the time-orientation of a computerized information system is primarily influenced by the degree of dynamism of uncertainty. Second, it is hypothesized that the complexity of a computerized information system is related to the degree of complexity of uncertainty.

Using the classification-schemes, the characteristics of a computerized information system are listed in Figure 5.4 (the boxes in Figure 5.4 are denoted as matrix-components). The characteristics are classified in terms of complexity and time-orientation, and cross-classified in terms of data base, reports and processing. The bases for identifying the characteristics is their power for discriminating among computerized information systems.

The characteristics will be described below and their relations, if any, to the reviewed generic characteristics noted. Characteristics which fall under the same classification (each box in Figure 5.4), are discussed together.

5.3.1 Characterizing the complexity of a data base

To describe the complexity of a data base (Figure 5.4 box 11) the scope of a data base needs to be explored. The characteristics proposed are: territory, integration, centralization and information reference. They correspond to some aspects previously reviewed: scope, extending from local to global (Carroll 1967, Galbraith 1973), centralization (Gordon & Miller 1976), orientation or genesis, extending from internal to external (Gordon et al 1978, Gordon & Miller 1976, Swanson 1978), and integration (Rørsted 1963). To these completeness has been added.

	COMPLEXITY OF SYSTEM	TIME-ORIENTATION
DATA BASE	Territory Integration Centralization Completeness Information reference 11	Frequency of collecting Collection delay Storage period 12
REPORTS	Variability Mode of presentation Value reference 21	Frequency of reporting Distribution delay Period reference Life-time of report-type 22
PROCESSING	Program origin Operations 31	Processing delay Ordering delay 32

Figure 5.4 Generic Characteristics of a Computerized Information System

Territory refers to the extent to which information systems are computerized in a collection of interdependent information systems supporting the same organizational activities. Only if all the systems are computerized, the computerized information systems taken as a whole are regarded as global. The computerized information systems are local if they consist of a pure subset of the interdependent information systems. For example, in a set of information systems consisting of purchasing, manufacturing, stockholding, order processing, order statistics, invoicing and sales statistics, a computerized information system consisting of stockholding and order processing is local, as is a computerized information system consisting of order processing, invoicing and sales statistics. When comparing two sets of local computerized information systems, it is only possible to say that one set is less local than the other when the second set is included in the first. In order to compare the territories of local computerized information systems, it is necessary to indicate the contents of the local computerized information systems.

The selection of information systems for computerization may be contingent on the context of the organization. It should be noted that territory in the sense used here does not imply that a computerized information system has to provide an activity with all the information needed for that activity.

A computerized information system is *integrated* if data from a system is used in other systems, for example data may be used concurrently in several systems from a common data-base or data may be used in the next system. Two computerized information systems are integrated if the information used or produced by either computerized information system is available to the other one without the need for further recording or intervening non-computerized operations. For example, in an integrated order-processing and stockholding system it is possible to check what is in stock at the same time as the order is processed. Integration is considered independent of territory.

A computerized information system is *decentralized* if it is not used by every organizational unit. In this case there may be more than one computerized information system performing the same kind of function in different units, and in the extreme case one for each organizational unit. The system is centralized if it is used by every organizational unit performing the corresponding function. For example, order processing is centralized when all divisions in a company use the same computerized routine for order processing; it is decentralized when the divisions use separate computerized order processing systems.

A computerized information system is *complete* if every case (for example every type of invoice) can be processed by computer; otherwise it is partial. For example, a computerized routine for invoicing is partial if it can handle domestic invoices but not export invoices, provided the organizational unit is selling both on the domestic and on the export market.

The *information reference* describes whether information is internal or external. It has been argued that a comprehensive understanding of organizations requires some knowledge of: internal processes, processes in the environment, and exchange processes between an organization and its environment (Emery & Trist 1965). Similarly information may refer to the organization, the environment, or the exchange-relations between an organization and its environment. Internal information refers to internal aspects of an organization. It is highly unlikely that any existing computerized information system will contain information about the environment (for example about relations between customers). Hence the term external information will be used to refer to information about exchange-processes (another possible term could be boundary-information). Invoices, sales orders and sales prognoses are examples of external information; machine capacity is an example of internal information.

5.3.2 Characterizing the complexity of reports

The presentation and combination of information are regarded as important elements determining the complexity of reports. (Figure 5.4 box 21). It is suggested that these elements can be

characterised in terms of the following features: variability, mode of presentation and value reference. It will be observed that these features correspond to some of the aspects already described, including: active and passive (Damodaran et al 1974, Losty 1971, cf Figure 5.2), format and method of reporting (Gordon et al 1978, Gordon & Miller 1976), time horizon and time element (Gordon et al 1978, Gordon & Miller 1976).

The *variability* of reports refers to the degree to which reports are variable or fixed. If a computerized information system produces only pre-specified reports (as in an active system), i.e. the kinds of information in a report has been pre-determined, then the report is described as fixed. In such a system, the user may receive the same reports each time or be able to choose from a package of fixed reports. If users are able to request and specify reports, which were not pre-determined at design (as in a passive system), then the reports are described as variable. It is a prerequisite for such reports, that the information needed is contained in the data base. Using a report-generator provides opportunities to produce variable reports and makes it possible to segment and organize information sets. While variability possible with a report generator is limited, it can be increased by using more flexible and sophisticated tools such as query-languages.

The *mode of presentation* refers to the manner in which the information in a report is presented or displayed. Many different modes of presentation are possible: tables, graphs, diagrams, histograms, with or without explanations, etc. The most common mode of presentation in computerized information systems is tables with limited explanations. Graphs, diagrams and visual displays are rare. This may be because special software or graphical CRT-terminals required for such displays involve a considerable extra investment.

The *value reference* of a report refers to the forecast or historical nature of the information it contains. Historical information describes what has actually happened or what is actually the state of things. Forecasted information can be divided into future forecasted, which refers to what is expected or planned to occur (what one believes may or will happen), and past forecasted, which refers to what was planned to occur (what one believed might or would happen). Forecasted information includes prognoses, plans and budgets. Historical information and past forecasted information may be compared, for example by comparing budget-data with actual outcome-data. The distinction between the future and past tenses of forecasted information involves not only the value reference but also the period reference, a concept to be introduced later (section 5.3.4).

5.3.3 Complexity of processing

When considering the complexity of processing (Figure 5.4 box 31), the rules and operations for manipulating information come into focus as important elements. Two features that are thought to be relevant here are operations and program origin. It has previously been suggested that the aspects information support and decision support (Edström 1973, Alter 1977) involve a continuum from simple data manipulations to the use of decision models. This implies a wide spectrum of operations. However, it was also noted that a more limited set of operations is usually found in EDP-systems than in decision support systems.

The *operations* of a system describe how information and data are manipulated. Five operations are identified: updating, aggregating, searching, transposing and inferring. Updating and aggregating are the most common operations, and are performed by most computerized information system. They may therefore be considered as elementary or fundamental operations. Searching involves searching for data, triggered for example by a query. Transposing can be used when data have several descriptors that may be used as identifiers, and it implies letting concepts used for headings and sub-headings in a report change roles. For example, sales-information may be presented with products as headings and customers as sub-headings. After transposing the data, sales-information may be presented with customers as headings and products as sub-headings. Inferring involves the use of simple decision rules and models. For example, order-quantity may be computed by means of the Wilson-rule.

There is an extensive supply of standard-programs for different applications from computer manufacturers, software houses etc. The use of such standard-programs varies, although it is apparently more common for accounting than for other types of applications. *Program origin* refers to whether the application-programs used in a system are acquired from some external supplier or designed within the user-organization. Note, only application programs are included here, not data base systems, operating systems and the like.

5.3.4 Time orientation

The concept of time orientation (Figure 5.4 boxes 12, 22 and 32) includes such factors as the age and currency of information, time-intervals and the like. The characteristics proposed to describe this concept are as follows: the frequency of collecting, storage period, and period reference (box 12); the frequency of reporting, period reference, life-time of report-type, and distribution delay (box 22); processing delay and ordering delay (box 32). These derive from the time-aspects previously reviewed (sektion 5.2.3) which included: timing (Carroll 1967, Galbraith 1973), frequency of reporting (Gordon et al 1978, Gordon & Miller 1976), time horizon and time element (Gordon et al 1978, Gordon & Miller 1976).

In previous studies, timing has been considered in terms of the frequency and speed of communication. In the work described here, frequency of collecting and reporting correspond to frequency of communication. Collection delay, distribution delay, processing and ordering delay correspond to speed of communication.

When considering the time-orientation of a data base (box 12) the focus is on the age of information. Thus, *frequency of collecting* refers to how often information is collected. It can be dichotomized into continuous and periodic collecting. Information may be collected periodically as often as each day and as seldom as each month. *Collection delay* refers to the time between the occurrence of an event and its subsequent recording. Ideally, information should be collected immediately without any delay.

The *storage period* describes the length of time data are stored and the period of time for which there is stored data. For example, data are sometimes stored for a year, in which case comparisons are possible a year back. However, sometimes only data for the present calendar-year are stored. In this case, comparisons are possible only within the current calendar-year and no comparisons can be made with data a year back.

When considering the time orientation of reports (box 22) the focus is on time-intervals and the currency of information. *Frequency of reporting* refers to how often information may be reported and can be dichotomized into continuous and periodic. *Distribution delay* refers to the time between the production of a report and its receipt by the user.

The *period reference* describes the time span covered in a report. It therefore includes both the length of the period and whether it is a past or a future period. (The combination of value reference and period reference has already been explored). *Life-time of report-type* refers to the period during which a report may be produced. The life-time for fixed reports corresponds to the life-time of the computerized information system. In the case of variable reports the life-time is usually limited and has to be defined when the report is requested. A variable report may be produced only once or several times. In the latter case its life-time is longer.

The time-orientation of processing (box 32) describes the time-aspects of processing, for example turn around time and waiting-times. *Processing delay* refers to the time between recoring information and producing a report. *Ordering delay* refers to the time between ordering and receiving a report. Ordering delay is not relevant for fixed reports since such reports by definition cannot be requested.

Having defined the relevant concepts, reference must be made to the relationships between them. First, the relation between frequency of collecting and reporting has already been noted. Secondly three delays — collecting, distribution and processing delay — account for different portions of the time-interval between event occurrence and the presentation of information about the event to a user.

5.4 Conclusions

The aim of this chapter has been to develop a model for describing computerized information systems. A number of content-oriented and generic models have been reviewed. Content-oriented models referred to the kind of data computerized information systems collect or the application areas of computerized information systems. Generic models included models which could be grouped according to components, coupling and properties of computerized information systems. The models reviewed were found to be less satisfactory than the one proposed for several reasons: they were less generalizable, and they did not sufficiently take into account the relations between the characteristics of computerized information systems and the complexity and dynamism of uncertainty and the contextual factors.

A content-oriented model has been derived to cover specific application areas. The model describes those computer systems which deal with production data. It has been subclassified on the basis of more detailed categories of data which are related to those activities in the production system of an organization responsible for receiving materials, converting them and delivering products.

The development of a generic model, however, has been the main focus of the chapter. This model contains several characteristics of computerized information systems. The characteristics are first classified in terms of the complexity and time-orientation of the systems, which are related to complexity and dynamism, respectively of uncertainty. Second, they are cross-classified in terms of data base, reports and processing, which are related to the functions of an information system, i.e. to collection, storing, processing and presenting information.

A model for describing computerized information systems is proposed. In deriving the model, the models previously reviewed are used. The properties in these models have been analyzed with regard to overlaps between properties as well as with regard to sub-aspects of properties (e.g. timing was found to have a number of sub-aspects). Based on the analysis of the properties they have been redefined, in some cases even renamed. Some new characteristics have been added. Finally the properties have been integrated into a coherent framework for computerized information systems.

This chapter has proposed a model for describing computerized information systems. To the extent that the characteristics suggested are grounded in available models and theories, the model proposed is theoretically and lexically supported. It remains, however, to demonstrate whether the model is appropriate and how the characteristics are influenced by contextual factors. This will be done in chapter 8.

6. RESEARCH STRATEGY – METHOD AND DESIGN

In previous chapters a theoretical frame of reference has been outlined, within which selected aspects of computer system design, organizational context and computerized information systems were discussed (chapters 2, 3 and 5). Further some preliminary hypotheses concerning the impact of contextual factor on computerized information systems were presented (chapter 4).

In this chapter the method and design of the empirical study are presented and discussed.

The study is an exploratory one with the purpose of generating hypotheses based on empirical data from nine case-studies. The empirical results are reported in chapters 7 and 8 and summarized in chapter 9. The appendix gives details of the organizational contexts as well as the links between those organizational contexts and computerized information systems.

6.1 A proposed framework

It has been suggested previously (chapter 4) that a computerized information system is influenced by the context of an organization. A framework depicting this influence and emphasising the factors considered in this study is proposed in Figure 6.1.

In the framework proposed computerized information systems are considered contingent on the two contextual factors environment and technology. These factors have been examined previously and more detailed concepts proposed. A number of environmental variables and technological variables have been outlined (chapter 3). Further a model of the characteristics of a computerized information system has been suggested (Figure 5.4).

The framework as outlined has a number of limitations. Specifically several factors and relationships are ignored. (These are either not indicated or indicated by dashed lines).

First, the influence of size has been ignored or, more precisely, controlled for as all companies selected belong to the same size-category (chapter 3 and 7).

Second, it has been argued previously (chapter 1) that computerized information systems constitute part of the structure of an organization. However, the influence of other structural features is not explicitly considered in this study. Depending on the type and extent of departmentalization and lateral relations different computerized information systems may be required.

Third, the ways in which structural factors constrain an organization's choice of environment and

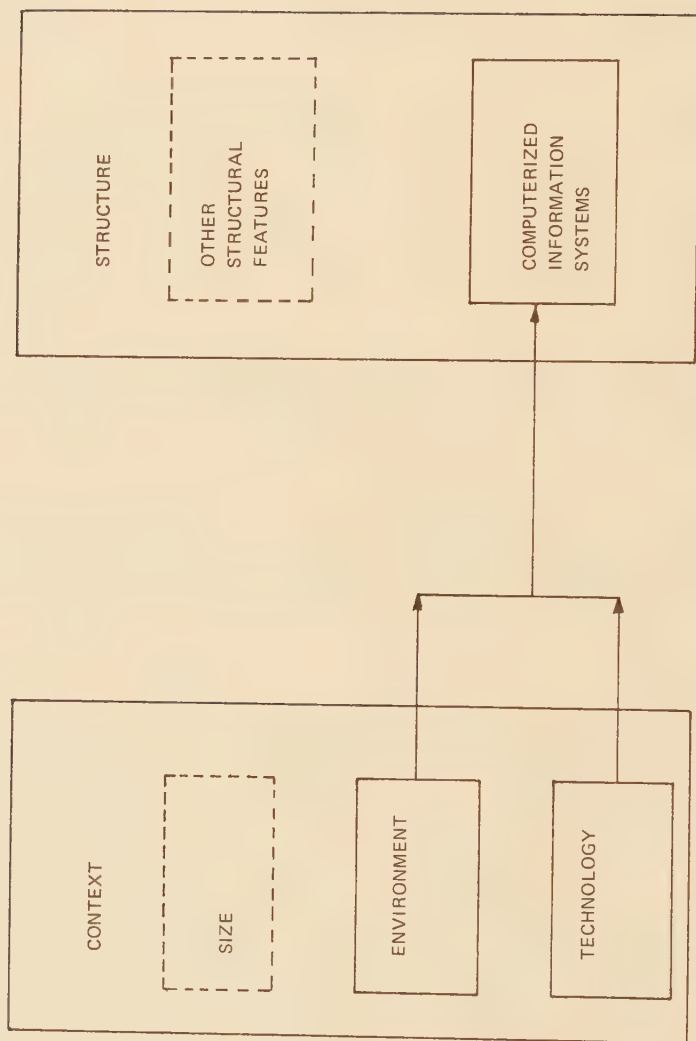


Figure 6.1. Main Factors Influencing the Characteristics of a Computerized Information System

technology have not been explicitly considered. More specifically, it has not been possible to explore how a computerized information system may constrain the choice of environment and technology by only making certain kinds of information available. To do this would have required a longitudinal study which was not feasible with the time and resources available.

Fourth, only production technology is considered and information technology is ignored. Depending on the information-technology available in an organization different computerized information systems may be possible.

6.2 Research strategy

6.2.1 Research process

The research process has comprised two main activities: concept development and empirical studies. These two activities, or sub-processes, are depicted in Figure 6.2.

The concept development process started with the two main factors or areas suggested by the overall theoretical framework i. e. the organizational context and the computerized information systems. The original crude concept categories have gradually been refined and redefined and the resulting finer concepts organized into a conceptual scheme.

The collection of empirical data was undertaken in parallel with the process of conceptual development. The data were collected by means of case studies of computerized information systems in nine companies. Some companies with various levels of computerization were chosen. The data were collected in these companies on the basis of the initial, crude concept definitions. In analyzing the data, the more detailed and refined conceptual scheme was used.

As already noted, the two research processes took place in parallel. The process of concept development has both influenced the collection and analysis of empirical data and itself been influenced by examples from the case studies.

Together, these activities have resulted in the formulation of a set of hypotheses. These are described in Chapter 8 and constitute a detailed elaboration of the relationships between the two main contextual factors, environment and technology, and the characteristics of computerized information systems.

6.2.2 Developing concepts

Three factors were identified initially as important: These were environment, technology and computerized information systems.

The criteria used to define those global concepts involved consideration of their semantic and operational aspects. The semantic aspects refer to the meaning and to the origin of concepts. Semantically a concept may have several submeanings. In addition, different concepts may have overlapping meanings. The semantic aspects were analyzed in order to separate and define the submeanings, and as far as possible to remove any overlaps. Where the meaning and lexical definition of concepts agreed to a very high degree, these concepts have been combined and consolidated.

The operational aspects of the concepts involve the possibilities for measuring and assigning the concepts to empirical phenomena.

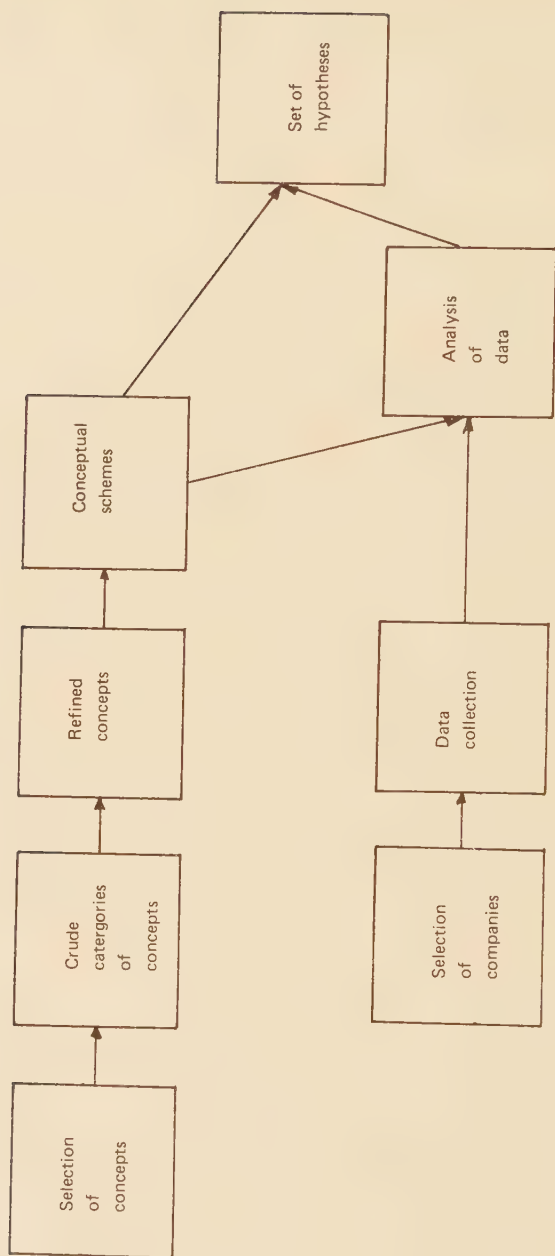


Figure 6.2. The research-process of the study

6.2.3 Case - studies

The study of organizations can be approached in at least three ways: surveys, case-studies and experiments. A survey covers a large number of factors or variances, and it usually presumes a high level of knowledge relevant to the research problem. An experiment allows the researcher to construct and manipulate very large conceptual models. Case-studies involve the intensive study of one, or a limited number, of factors or variances.

Case-studies were chosen as the approach for the present study for the following reasons. First, existing knowledge of the links between organizational contexts and computerized information systems was regarded as being too rudimentary for a survey to produce anything but superficial results, probably at a considerable cost. Secondly, it was also highly doubtful whether the complex relationships to be explored in the study could be addressed at all meaningfully in a survey. Similar arguments were considered to apply to the experimental approach. Finally, since the present study was exploratory and its objective was to form a set of hypotheses, the method adopted would need to provide for the collection of detailed data on a number of aspects. This was regarded as being a further argument for the adoption of a case-study approach.

Having selected a case-study approach a further question to be resolved was the number of cases to be examined. The choice here ranged from a very intensive study of a single organization to the study of a number of organizations. In order to be able to form hypotheses under different combinations of the two contextual factors (Figure 6.1), it was clear that several organizations having different contexts needed to be studied.

Nine organizations were finally selected. They were subsequently classified into five groups on the basis of their contextual characteristics (cf chapter 7). Two groups comprise one company each; another two groups two consist of companies; and finally, one group contains three companies.

Since the sample sizes involved are small, the results cannot be statistically validated. The choice between small and large samples depends on what is to be studied and on the research purpose, specifically whether it is to generate or to test hypotheses. The small sample has often proved superior in generating hypotheses and small samples and the use of simple and more direct methodologies often yield more useful results (Mintzberg 1979).

6.3 Research methods of the study

The research methods involve choosing the objects for study and collecting, analysing and presenting the data. The data collected give a picture of the context and the computerized information systems of an organization at a point of time.

6.3.1 Selecting companies

In selecting companies, the overriding criteria were the possibilities for comprehensively illustrating the concepts. Thus companies needed to have different levels of computerization.

In order to select suitable companies, several sources were used. These included professional computer-journals and conferences on computerized information systems at which particularly interesting papers are often presented. These presentations provided an important source for choosing companies. Discussions were also held with a few colleagues.

Finally, nine companies were selected for the case studies. They were based in different manufacturing industries and had reached different levels of computerization, several of them having used computers for more than ten years.

A further question concerned selection of the applications to be studied. The choice itself was not critical, but it was important to investigate computerized information systems within the same area of application in order to avoid differences relating to subject area.

The computerized information systems studied are those concerned with activities for acquiring, converting and disposing of materials and products, particularly in the production system of an organization. These computerized information systems include stock control, production control, material administration as well as invoicing, order-entry and statistics. Computerized information systems concerned with accounting and finance are not included in this investigation. Although the types of computerized information systems studied appeared under different headings within the various companies, these headings have not been retained in this report. Instead common labels have been introduced.

6.3.2 Data collection

The framework depicted in Figure 6.1 indicated those factors — environment, technology and computerized information systems — for which data were relevant.

Several sources were used in collecting data:

- interviews
- written material: business press, annual reports, computer system documentation, examples of computer printouts.

Both users and designers of computerized information systems were interviewed. No structured interview-form was used. However, there was a list of certain areas and concepts to be covered, although the sequence in which they were introduced varied with each interview. An average of five individuals was interviewed in each company. The interviews lasted from half an hour to two hours, with two hours being the most usual length. The interviews were conducted during the spring and autumn of 1977, with the exception of two companies where interviews had been conducted previously.

The interviews with users concerned computerized information systems in general, their use of reports from computerized information systems and the factors that influenced their tasks. The interviews with system designers concentrated on the computerized information systems: including when they had been designed, their inputs, files and output, how often they were run, what system documentation existed.

Whenever possible, written material on the computerized information systems was collected. In some cases user documentation, describing how to order reports, or examples of computer printouts, was provided. It appeared however that there was very little system documentation in most companies. Among the reasons given for this were: first that the computerized information system was very old, changes had been made and hence any documentation would provide a distorted picture at best; and second, the existing computerized information system was due to be replaced by a new one, or the design of a new one would start in the near future; they were thus too busy designing and maintaining computer systems to be able to reserve resources for documentation.

6.3.3 Analysis of data

The interviews have all been transcribed and analyzed, using the conceptual scheme developed. Tables and matrices have been constructed, presenting different characteristics of computerized information systems in relation to environment and technology (cf chapter 8).

The first stage of the analysis involved grouping the companies according to their context. First groups were formed on the basis of technology and second in relation to environment (cf chapter 7).

Then the characteristics of computerized information systems were analyzed, and hypotheses formulated concerning the links between characteristics of computerized information systems and the two contextual variables. (see chapter 8).

6.3.4 Presentation of data and results

The empirical part of the study is presented in chapters 7 and 8. Short descriptions of each company are provided in chapter 7, and more detailed information on all companies is contained in the appendix. The descriptions in the appendix follow a common format. The names of the companies participating in the study have not been revealed.

The research results are summarized in chapter 9 and the hypotheses formulated are listed. Furthermore some implications for the design and use of computerized information systems are presented.

7. ORGANIZATIONAL CONTEXT

In previous chapters, the theoretical frame of reference has been introduced and made explicit. The proposed framework has been presented (chapter 6) and a model formulated, which depicts the contextual factors influencing a computerized information system. The two contextual factors, technology and environment, have been identified and their characteristics discussed (chapter 3). Specifically, a model for describing computerized information systems has been put forward (chapter 5).

This chapter contains a description of the context of each of the organizations participating in the study. This material forms the basis for the development of a way of indentifying and classifying different types of organizational context. In Chapter 8, the characteristics of the computerized information systems operating in each of the companies will be described and their relationship to the contextual factors established. Finally, some conclusions and general hypotheses will be put forward in Chapter 9. Only brief case-descriptions are presented in this chapter, the detailed ones can be found in an appendix.

7.1 Plan of the chapter

The purpose of this chapter is to identify groups of companies¹⁾ based on organizational context. Each company is described briefly and its major features emphasized (section 7.2). In that way, a basis is established for discussing technological types (section 7.3). The grouping of companies based on technology may however be modified by environmental influence, hence sub-groups of companies are formed (section 7.4). Finally additional factors may play an important part in the relation between organizational context and a computerized information system (section 7.5).

There are a number of ways of defining types of context. The contextual factors identified in the present study are technology and environment, hence types of context can be defined in terms of (1) technology alone, (2) environment alone, or (3) a combination of technology and environment (one factor used for primary definition of types and the other for supplementary definition). The first two alternatives have certain drawbacks. Types of context defined on the basis of technology alone do not account for differences between companies related to environment; similarly, classifications based on environmental aspects alone may be limited by not taking technology into account.

Thus, the third alternative, which combines technology and environment, has been chosen. As

¹⁾ Group of companies will be used to refer to companies belonging to the same contextual type. Company group will be used in the legal sense.

the computerized information systems under study are primarily concerned with internal administrative work, it is assumed that technology will have more influence on their characteristics than will the environment. Accordingly, technology will be used for the primary definition of contextual types and the environment for supplementary definition.

7.2 Brief case-descriptions

Nine companies have been studied. The companies will be described separately (in alphabetical order) and the main features of each company discussed in this section. Only brief descriptions will be given, since the detailed case-descriptions are to be found in an appendix, where each company is described following a common format.

7.2.1 *Big Mill Division*

Big Mill Division belongs to a Danish company group which operates in a variety of industries, from foodstuffs to engineering products. The group started by producing and selling a foodstuff which is still the major product in the group. Big Mill is the division in the group that produces and sells this foodstuff.

There have only been minor changes in the markets of Big Mill. The volume of business has remained the same for a long time. Although some of the foodstuff produced is exported, the major part is sold on the domestic market, to wholesalers and industrial customers. There is a limited number of customers.

The necessary raw-materials are acquired exclusively from domestic suppliers. Big Mill needs to ensure a smooth and reliable supply of the raw-material, hence relations with suppliers are important. Big Mill relies on a large number of regular suppliers.

Big Mill has a dominant market share. Competition in the domestic market has remained the same for a considerable period, during which there have been no changes in the number of competitors whose market shares have remained roughly the same. The product is only exported to those markets where either domestic suppliers cannot satisfy the local demand or where there are no domestic suppliers.

Another important element in the environment of Big Mill is those regulations which affect the volume of business, the supply of raw material and prices. The purpose of these regulations which have mostly been long-term, is to ensure a reliable and regular supply of the foodstuff independent of ups and downs on the world market and to allow for some export. Even though there have been changes in the nature of the regulations, for example at the time of Denmark's entry into the Common Market, these changes have not significantly altered the volume of business.

Production is based on two production systems which are largely independent of each other. The first involves extracting the product from the raw material through a system of process production. The second involves filling batches of containers with the product, and can be described as large batch production. There have not been any radical changes in the principles of technology, though the degrees of automation and mechanization have increased so that extracting the product is now completely automated.

Big Mill is an experienced user of computers, as are other divisions in the company group. The company group has a central unit for developing, maintaining and administering computerized information systems and central computer facilities.

The computerized information systems in Big Mill covers purchasing, manufacturing, stockholding, invoicing and sales statistics. They have been developed specifically for Big Mill and are not used by other divisions in the company group. The computerized purchasing system is the

biggest computer system in the entire company group. The computerized information systems in Big Mill are all batch processing systems, and produce reports with a fixed, tabular format. Only domestic transactions are processed, hence the stock-holding, invoicing and sales statistics are partial. The computerized information systems are primarily run on a weekly and monthly basis.

7.2.2 Consolidated Mill Division

Consolidated Mill Division is a division of a Swedish company. The company was founded with the purpose of producing and selling foodstuffs. However, by developing and adding new products, the company has diversified and it now does business in a number of industries. The original product is now the responsibility of Consolidated Mill.

There have been some changes, none of them radical, in the environment of Consolidated Mill. The whole production output, plus a minor variable amount of import, is sold on the domestic market to industrial customers, wholesalers and retailers.

Consolidated Mill needs to ensure a smooth and reliable supply of raw materials, hence good relations with suppliers are highly valued. Consolidated Mill relies on a large number of suppliers, most of which are small. The majority of the suppliers are regular but each year there are some new ones. The suppliers are all domestic.

Consolidated Mill has been the only producer and seller of the product since the 1930s. The company is also the main importer although industrial customers sometimes import the foodstuff for their own use.

A last important element in the environment of Consolidated Mill is the regulations which affect the volume of business, the supply of raw material, and prices. The time spans covered by these regulations have varied, from one to five years. They have specified a varying level of domestic production, sometimes decreasing and sometimes increasing output levels. Their purpose has been to adapt Swedish conditions for producing the foodstuff to world market prices.

Production consists of two systems, which are largely independent of each other, and which work in different cycles. The first production system extracts the product from the raw material, through a system of process production. The second involves filling batches of containers with the product, on a large batch production basis. There have been no radical changes in the principles of technology although the degrees of automation and mechanization have increased, particularly in those activities involving extracting the product.

At the time of study, Consolidated Mill had used computers for about ten years. Consolidated Mill is the only division in the company group which has resources for developing, maintaining and administering computerized information systems. These resources also serve other divisions in the company group. The computerized information systems used by Consolidated Mill cover purchasing, manufacturing and stock-holding. They are used only by Consolidated Mill. The computerized information systems are all batch processing systems. Reports, following a fixed tabular format, are produced at regular intervals, mainly weekly but also daily.

7.2.3 Container Division

Container Division manufactures and sells containers. It is one division of a diversified company group in which the other divisions manufacture and sell different types of products.

Over the years, the volume of business has increased for the division. The markets, domestic as well as foreign, seem to continue to expand.

Container Division has a large number of regular customers, who rely on a steady supply of con-

tainers. The customers all belong to the same or closely related industries.

The need to produce an uninterrupted supply of containers for its customers has made the relationships of the Container Division with its suppliers important. Some important high-volume rawmaterials are bought from a limited number of suppliers in different parts of the world.

The customer orientation of the division demands a smooth production process. Production has a short turn-around-time and the process can be divided into three steps. Containers are produced in large batches using a high degree of automation.

Container Division is an experienced and imaginative user of computerized information systems. The division has access to central resources for developing, maintaining and administering computerized information systems, and it uses the central computer facilities of the company group. The computerized information systems consist of manufacturing, stock-holding and order-entry, and they are used only by Container Division. They are all batch processing systems which produce fixed, tabular reports regularly, primarily daily or weekly.

7.2.4 Decor Division

Decor Division manufactures and sells a line of products for interior decoration in private as well as public areas. The division belongs to a company group that also makes other types of products for different markets.

The product manufactured by Decor has been on the market since the 1920:s. The arrival of new and better raw materials has meant changes in the composition of the product, it has also made it possible to offer a wider product range.

The volume of business has remained the same for a number of years. The division is sensitive to changes and business cycles in customer industries, and some important markets have disappeared. As a consequence the need to find new application areas and markets for the line of products has been considerable.

The division has both domestic and foreign customers and approximately half of the production output is exported. The product is sold to wholesalers, retailers and a number of large users.

The decline in markets has increased competition on both remaining and new markets, domestic as well as foreign. The competition comes both from manufacturers of the same kind of product and from manufacturers of products with similar application areas.

Raw materials are supplied from several sources. Some raw materials are supplied by other divisions in the company group.

Decor Division is an experienced and advanced user of computerized information systems. It is the biggest user in the company group, both in absolute terms and relative to the size of the division. There is a central unit for developing, maintaining and administering computerized information systems and central computer facilities (though some computer power has been decentralized) in the company group.

The computerized information systems in Decor cover stock-holding, order-entry, order-statistics, invoicing and sales-statistics. They are used by most divisions in the company group. In some cases they were designed originally for Decor but have later been amended to enable use by other divisions. Order-entry and invoicing are direct processing systems, the remaining computer systems are batch processing systems. Tabular reports are produced regularly (daily, weekly or monthly). The order-statistics and the sales-statistics systems have facilities for requesting and specifying reports.

7.2.5 Light Engineering Division

Light Engineering Division manufactures and sells a safety device. The division has only one product with a small number of variations. Light Engineering belongs to a company group which also produces other types of products.

The product is a new one. It is an automatic and technically advanced product. Existing, competing products are non-automatic.

The sales volume has grown steadily and the prospects are regarded as good in both the domestic and export markets. The number of customers is limited, since the product is used primarily in certain types of heavy equipment. Competition comes only from manufacturers of similar but non-automatic devices, and the market is supplied by a small number of well-established manufacturers.

The product is a safety device, hence there are strict requirements for the raw materials, parts and components used in production. So relations with suppliers are important.

Production is in large batches and consists of two steps. Both steps are automated and mechanized to a large extent. There have been no radical changes in the principles of the product nor in the production process, although changes have been introduced in order to increase efficiency of production.

Some components are manufactured by the division, but most components and parts are bought in or sub-contracted. The division then assembles the components and parts. Production hence consists of two steps.

Light Engineering Division is the most experienced user of computers in the company group. In addition to the central resources in the company group the division has a small unit for developing, maintaining and administering computerized information systems. The division has no computer of its own.

The computerized information systems cover manufacturing, stock-holding and sales-statistics. The sales-statistics system has been developed centrally and is intended to be used by all divisions, while the manufacturing and stock-holding systems are used only by Light Engineering. The systems are all batch-oriented. Reports in a fixed, tabular format are produced periodically with intervals of at least a week.

7.2.6 Machine Division

Machine Division develops, manufactures and sells a few varieties of engineering products. It also supplies spare parts. Other divisions in the same company group manufacture and sell different types of products.

The products have limited application areas and are sold to domestic as well as foreign customers. The market has increased steadily, but the increase is not uniform across products. The market for some of the products is mature, while that for other products is still growing.

Machine Division has a large number of customers and potential customers. Its competition comes from other manufacturers of similar products, though Machine Division has a dominant share of the market.

Machine Division relies on many suppliers who, in some cases, have become dependent on Machine Division for their continuing production.

The product has a long through-put time and is manufactured in small batches. The amount of

of assembling done by Machine Division varies across different products. The addition of new product varieties has often meant the introduction of different methods (or steps) of production.

Machine Division is an experienced user of computers. Computerized information systems are used for purchasing, stock-holding and order-entry. These computer systems are used only by Machine Division. They are all batch processing systems. Reports, in a fixed and tabular format, are presented regularly, daily or weekly.

The company group has central computer facilities and central resources for developing, maintaining and administering computerized information systems.

7.2.7 Parts Manufacturing Division

Parts Manufacturing Division manufactures and sells moulded products used as parts or components in products manufactured and sold by other companies. There are standard products as well as products commissioned by customers.

Parts Manufacturing belongs to a company group, the other divisions of which manufacture and sell different products.

During recent years, the difficulties in the Division's markets have increased and sales levels are stagnating or even declining. Domestic sales dominate, only a small portion of output being exported. As many products are commissioned, relationships with customers are important. Competition has increased and there are several competitors who make or have the capacity to make similar products. The division has a reliable supply of the basic raw material which is used in large quantities.

Production consists of a number of steps which all products pass through in the same order. Certain types or products may require special processing, in which case an extra step is added to the process. The products are manufactured in large batches, standard products being made for stock and other products being made to order. Some stages in production are still primarily manual while others are heavily automated or mechanized.

The Parts Manufacturing Division is an experienced user of computers and has access to modern computer facilities. The company group has a large central unit for developing, maintaining and administering computerized information systems. The computer facilities are also centralized.

The computerized information systems used by Parts Manufacturing cover manufacturing, stock-holding, order-entry and sales-statistics. Some other divisions in the company group, although not all, also use these computer systems. Order-entry and stock-holding are direct processing systems, the remaining ones operating in batch processing mode. The batch processing systems produce tabular reports monthly. The sales-statistics system has facilities for requesting and specifying reports.

7.2.8 Standard Division

Standard Division manufactures and sells a line of standard products. Standard belongs to a company group which manufactures and sells other types of products; both standard as well as non-standard.

As a result of a major drop in sales for some of its products, Standard Division has discontinued manufacturing these goods. To replace these, the division has recently introduced a new line of products which have different application areas and are sold to other types of customers. The principles of technology are the same for the new line as for the old line.

The total market for the old line was decreasing, resulting in over-capacity. Competition hence increased and prices decreased to an unprofitable level. The market was dominated by large international manufacturers.

The old line was sold to wholesalers and retailers, and the difficulties in the market were aggravated by changes among customers. The new line is sold to customers who use the products as components in equipment they manufacture. The new line has few competitors, thus the competitive position of the Division is expected to improve.

The raw materials used are the same for the new as for the old line. Standard Division is provided with a reliable supply of the major raw materials.

Production consists of four stages, all products passing through the stages in the same order. The products are manufactured in medium to large batches and all are made for stock. While some stages in the manufacturing process involve the use of highly mechanized and automated equipment, others are predominantly manual.

All the divisions in the company group use the powerful central computer resources and the central staff-unit for developing, maintaining and administering computerized information systems.

The computerized information systems used by Standard cover manufacturing, stock-holding and sales-statistics. These computer systems are used only by Standard. They are all batch processing systems, and fixed, tabular reports are produced with frequencies of two days, a week or a month. The computerized information systems are used for recordkeeping and for providing the necessary data for planning.

7.2.9 Suction Division

Suction Division sells specialized, technically advanced products, a line of heavy engineering equipment, which are used in several types of industries. Products manufactured by Suction are supplemented with products from other manufacturers in order to be able to offer a complete range of products. The nature of product range makes it necessary for Suction to supply spare parts.

Suction is a division in a company group which manufactures and sells a wide variety of products.

Suction is dependent on the markets and business cycles of its customers. At the time of this study, some markets had disappeared and others were having difficulties, resulting in stagnating business and the need to find new geographical markets. There is a limited number of customers in each industry and geographical area. The number of competitors is limited but it is particularly hard to enter new markets. Suction uses a number of rare raw materials in manufacturing its products, hence a reliable supply of these materials is essential. Other types of raw materials are supplied from several sources.

Suction is a small user of computerized information systems. The division has some resources for developing, maintaining and administering computerized information systems and can use resources belonging to the company group as a whole. The division has no computer of its own.

The computerized information systems cover purchasing and stock-holding, which are mainly used for record-keeping. They are used only by Suction. Both computer systems are batch processing ones, which produce fixed, tabular reports weekly.

7.2.10 Common characteristics

The companies studied have been described briefly in the previous sections. Although there are a number of differences between them, not least the fact that they belong to different industries, they also have several characteristics in common. In particular, they are all large, manufacturing companies, with technologies of the long-linked variety (Thompson 1967).

It has been argued that the companies studied are large, even though the number of employees alone may not be sufficient to classify them as large. This is, however, compensated for by the fact that all the companies belong to larger company groups which have central units for developing, maintaining and administering computer system and central computer resources.

At the time of the study, the number of employees was around 2000 in two companies, Big Mill Division and Consolidated Mill Division, and between 400 and 900 in the remaining companies. The number of employees varied from 1000 to 6000 across the company groups.

The dividing line between small and large companies has been put at 1000 employees (Child 1977) or at 500 employees (ADB och Arbetskraften 1973, 1975). It may thus be assumed that companies having 500 to 1000 employees may have characteristics in common with both small and large companies. The characteristics of large companies will tend to dominate when a company belongs to a company group, since as part of company group a subsidiary company is able to develop more specialized competence than is a small independent company.

7.3 Types of technology

In the remainder of this chapter, the companies described in the previous section will be divided into groups based on a combination of the contextual factors, technology and environment.

The environment and technology of an organization are closely related, as is evident from many contingency studies, and a technological component is often included in the environment (see for example Duncan 1972, Khandwalla 1977). Indeed, they may be chosen concurrently together with the information system, as a result of some other common, superior factor, such as the organizational culture. The extent to which it is possible to separate the factors is therefore a matter of research design. In order to analyze the correlation between production technology and computerized information systems a major assumption is necessary. In this case the environment, will be considered as superior to and influencing production technology which is considered to be derived from the environment. It then follows that the direct influence of the environment on computerized information systems is secondary to that of the technology, while the indirect influence is important and can be extensive. It is therefore assumed that technology has a primary influence on those computerized information systems which are related to the production system of an organization. The direct influence of the environment is regarded as secondary and supplementary to that of technology on computerized information systems, however, the environment may exert an important indirect influence on technology. Accordingly, technology is used to obtain a first grouping of companies (section 7.3), after which environment of factor are used to obtain further subdivisions of the groups (section 7.4).

7.3.1 Types of technology — in general

A number of well-known approaches to typologies of technology have been discussed previously (section 3.4.3), particularly those suggested by Perrow (1970), Thompson (1967) and Woodward (1965). These typologies can be distinguished in terms of their degree of generality, level of analysis and the observability of the measures used. Perrow (1970) studies technology at an individual or group level of analysis (in relation to the work situation), while Woodward (1965) and Thompson (1967) consider technology at an organizational level of analysis. It has been argued elsewhere (section 3.4.3) that the typology suggested by Woodward (1965) falls within the long-

linked technology described by Thompson (1967), whose classification also incorporates mediating and intensive technologies.

As all the companies studied are manufacturing and an organizational level of analysis has been chosen, groups can be defined with reference to type of production. Accordingly the classifications of Perrow (1970) and Thompson (1967) are not applicable nor are they relevant. Woodward's model is well-known, and it comprises unit production, small batch production, large batch production, mass production as well as process production. Since the differences between some of these types may be relatively small, the number of categories can be reduced to three: unit and small batch production, large batch and mass production, and finally process production.

Small batch production comprises products made according to customer specification, and involves the manufacture of specialized products in short series (e.g. certain types of equipment, tools and measuring-instruments). Large batch production comprises production of standard products, usually with only limited adaptation to customer specification. Process production means continuous production of bulk-products (i.e. products measured in terms of weight or volume).

7.3.2 Empirical types of technology

It was argued in the previous section that the model suggested by Woodward (1965) can be reduced to three types of technology: small batch production, large batch production and process production. This typology cannot be used directly to classify the technologies of the nine companies studied, instead it is necessary to describe them first using a more detailed approach. It has therefore been suggested, in section 3.4.3, that technology may be described in terms of four technical components: products, work flow, material flow and techniques, each of which may be further characterized with regard to a number of technical variables (Figure 3.1).

Based on descriptions of the technologies of each of the nine companies studied in terms of the four technical components they were classified as small batch production, large batch production and process production. The classification of the nine companies and their technological descriptions are shown in Figure 7.1 and discussed below. It will be used later (see Chapter 8) in relating the characteristics of computerized information systems to technology.

The product may be characterized in terms of its dimensionality, standardization, line and age. Dimensionality is a term referring to whether production output is measured in relation to the number of units produced or its weight or volume. The number of units is the measure applied in small batch and large batch production whereas in process production output is measured by weight. Product standardization refers to whether the same or a different product is offered to different customers or for different application areas. Product standardization may increase the efficiency of production. In small batch production, products were specialized and may be adapted to customer requirements. In large batch production, there were standard products although additional specialized products may be made. Products were standardized in process production as it is a prerequisite for efficient production. The number of finished products in a line may vary from just a few to a large number. The line of products, referring to the range of products actually manufactured, was limited in process production and large in large batch production. In small batch production a large number of products may potentially be manufactured, however the actual line of finished products was found to fall between large batch production and process production. In addition, it was observed that spare parts were supplied in small batch production, but not in large batch and process production. With regard to the age of products, there were both young and old products in small batch production as well as in large batch production; however, the products made in process technologies were old.

Work flow is another technical component. It may be characterized in relation to sequence, length and interdependence. Work flow refers to the steps of production. The sequence of steps may vary between products or it may be fixed; similarly the length or the number of steps in the work flow may be constant or varying. In small batch production, both the sequence and

	Small batch production	Large batch production	Process production
	Machine Division Suction Division	Container Division Decor Division Light Engineering Division Parts Manufacturing Division Standard Division	Big Mill Division Consolidated Mill Division
Product — dimensional — standard — line — age Work flow — sequence — length — interdependence Material flow — continuity — stock policy — expansiveness — throughput-time Techniques — specialization — automation — capital intensity	unit products specialized medium varying variable varying sequential small batch order contracting long (months) non-specialized little automation low - medium	unit products standard and specialized wide varying fixed constant sequential large batch inventory and order expanding medium specialized highly automated high	by weight standard limited old fixed constant sequential I continuous inventory one-one short II large batch inventory expanding short specialized highly automated high

Figure 7.1 Characteristics of the three empirical technological types and the corresponding groups of companies.

length of the work flow may vary, some products requiring very few steps, others several steps. In large batch process production, the work flow is fixed and the length is constant for different products. Interdependence is sequential in all three technologies since the performance of one step requires that others have been performed.

A third technical component is material flow, which may be characterized in terms of continuity, stock policy, expansiveness and through-put-time. Production is continuous only in process production. In the other types, products are manufactured in batches, small and large respectively. Stock policy refers to whether output is made for customer orders or for stock. It was found that production was based on orders in small batch production and directed towards stock in process production. In large batch production some products were made on customer order, while others were made for stock. The material flow may be narrowing or widening, in respect of the relationship between finished products and raw materials, and this is referred to as expansiveness. The material flow is described as expanding, when the number of finished products exceeds the number of raw materials; it is labelled contracting when the number of finished products is fewer than the number of raw materials. In small batch production, material flow was found to be contracting; it was found to be expanding in large batch production; and it was found to be one-one in process production. Production has a long through-put-time in small batch-production and a short one in process production. The through-put-time in large batch production was found to lie between small batch and process production.

The last technical component consists of techniques, which may be characterized in terms of specialization, automation or mechanization, and capital intensity. The techniques and equipment used are standard in small batch production, but specialized in large batch production and process production. Likewise there is little automation in small batch production, while large batch production and process production in particular are highly automated.

Several of the characteristics discussed can be seen to be related to the requirements for flexibility in small batch production or to the requirements for efficiency in large batch production and process production. Specialized products manufactured in small batch require flexible production, which implies a variable work-flow and non-specialized techniques and equipment. Standard products can be efficiently produced in large batches, which make it possible to utilize more specialized and more automated techniques.

Other characteristics, such as expansiveness and stock policy, might have brought about further subdivisions of the three technological types.

7.3.3 Groups of companies formed

The technologies of the companies studied have been classified as small batch production, large batch production or process production as shown in Figure 7.1. The three groups of companies are presented below.

The technologies of two companies are classified as small batch production. They are Machine Division and Suction Division, both making engineering products. There is a minor point of difference between the companies concerning the age of products: the products manufactured by Suction are old, while those manufactured by Machine are young.

The technologies of five companies are classified as large batch production. They are Container Division, Decor Division, Light Engineering Division, Part Manufacturing Division and Standard Division. They represent different industries. The characteristics of one or two companies differ in some respects from those of the total group. Light Engineering Division, for example, has a product line consisting of essentially one product with a few variations; in addition, material flow is contracting (as in small batch production) and not expanding, as for other companies in the group. Production has a very short through-put-time in Container Division.

The technologies of the remaining two companies, Big Mill Division and Consolidated Mill Division are classified as process production. In practice, these two companies have two technologies, both of them operate large batch production as well as process production. The two technologies are to a large extent independent of each other.

7.4 Environmental influence

It has previously been argued that technology has a primary and environment a secondary influence on computerized information systems. In the previous section three groups of companies were formed on the basis of their predominant technology. In this section, environmental influence will be considered, and three empirical types of environment identified. As a result, the groups previously formed will be further subdivided.

7.4.1 *Environmental influence on technology*

A number of well-known approaches to and typologies of organizational environments have been discussed previously (section 3.4.2). These include those of Emery and Trist (1965), Thompson (1967), Duncan (1972) and Khandwalla (1977). These typologies can be differentiated according to the dimensions they use and the environments they studied. Duncan (1972), for example, considers both the internal and the external environments, while Emery and Trist (1965), Thompson (1967) and Khandwalla (1977) consider only the external environment. The main dimensions used to characterize the environment are dynamism and complexity. In this connection, it has been argued by Duncan (1972) that dynamism is the main characteristic of an environment, other dimensions describing only secondary features.

It is suggested that technology and environment are not independent. Perrow (1970) and Woodward (1965) argue that the environments of small batch firms, those of large batch firms, and those of process firms have different characteristics; process firms require assured markets, while small batch firms can adapt to changes in the market. Hence different technologies make different demands on the environment; the less flexible its technology the more stable an organization's environment needs to be, and the more important it is to be able to acquire raw materials and dispose of products. Conversely, the more static and the more simple an environment, the more the application of a less flexible technology may be encouraged. Similarly, the more dynamic and the more complex an environment, the more flexible an organization's technology needs to be, since the more important it is for an organization to be able to implement changes quickly.

It is further argued that the environmental influence on organizational structure increases in importance as the degree of dynamism in the environment increases. For some types of technology, the organizational environment may not play an important part as long as the environment is fairly static and simple. On the other hand, if some organizations have similar technologies, then the environmental influence on the structure of the organizations, including computerized information systems, may be more important in the dynamic and complex environment than in the simple and static environment.

7.4.2 *Empirical types of environment*

Using the characteristics discussed in section 3.4.2 three types of environment have been identified in this study. These are the stagnating, increasing and regulated environments. The three types of environment which characterise the nine companies are shown in Figure 7.2 and discussed below.

Previously (section 3.4.2) it has been suggested that environments may be described using four dimensions: changeability, complexity, hostility and restrictiveness. Any characterisation of an environment in terms of these dimensions will be a relative rather than an absolute description.

	Stagnating	Increasing	Regulated
	Decor Division Parts Manufacturing Division Standard Division Suction Division	Container Division Light Engineering Division Machine Division	Big Mill Division Consolidated Division
Changeability	most changing	slightly changing	least changing (fairly constant)
Complexity	complex	simple (or slightly complex)	simple
Hostility	hostile, lean	benevolent, rich	between hostile and benevolent
Restrictiveness	...	...	governmental regulations

Figure 7.2 Characteristics of the three empirical environmental types
(Note: The characteristics of one environmental type are relative those of other types).

For example, an environment is not viewed as changing in some absolute sense but rather is assessed as changing more than some other environment.

Changeability is the most important dimension and refers to the degree of change in an environment, varying from constant. The increasing environment was found to be less changing than the stagnating environment. In contrast to the increasing environment, the stagnating environment involved change in the number and types of competitors and of customers. The regulated environment was found to be fairly constant.

Complexity concerns the variety and similarity of environmental components, which may vary from simple to complex. The regulated environment was found to be the simplest, consisting only of a few similar types of components. The stagnating environment consisted of a large number of dissimilar types of components, so it was considerably more complex than the other two environmental types. Stagnation, in conjunction with increasing competition, may force a company to search for new types of customers and thus lead to a relatively more complex environment.

Hostility refers to the continuum of hostile and benevolent (or the related one of lean and rich). The stagnating environment was found to be lean and hostile, while the increasing environment was found to be rich and benevolent with many opportunities. There are higher risks in a hostile environment, for example with regard to selling products produced for stock, than in a benevolent or rich environment. The regulated environment was found to lie between the stagnating and the increasing environment on the dimension of hostility.

Restrictiveness refers to the existence of restrictions and regulations of different kinds. Of particular interest are those restrictions and regulations that are not common to all types of environment. It was only the regulated environment which was found to have any regulations of importance and these restricted operations in a number of ways. The regulated environment may be described as protected since regulations imposed important restrictions on both competitor and suppliers.

The classification of the environment of each of the companies is shown in Figure 7.2 and discussed below.

The environments of four companies — Decor Division, Parts Manufacturing Division, Standard Division and Suction Division — are classified as stagnating. These environments are changing, as the markets have to various extents disintegrated. The environments were found to be complex, because there are many types of environmental components, such as types of customers.

The environments of three companies - Container Division, Light Engineering Division and Machine Division - are classified as increasing. These environments are changing only slightly, as the markets are increasing based on unique products. In these environments, there exist a few types of customers and excellent possibilities of finding new markets; hence the environments are simple and benevolent.

The environments of the last two companies - Big Mill Division and Consolidated Mill Division - are classified as regulated. The regulations restrict production and market volume as well as the prices of raw material and finished products. The companies dominate their markets, competition is largely non-existent. Customers and suppliers are of a few types only, hence the environments are simple.

7.4.3 Combining technological and environmental types

In section 7.1 it was argued that subgroups of companies would be formed based on a combination of technology, as the primary variable of grouping, and environment, as the supplementary variable of grouping. The groups thus formed are listed in Figure 7.3. Although there are nine

		Stagnating environment	Increasing environment	Regulated environment
Small batch production	Machine Division Suction Division	Decor Division Parts Manufacturing Div Standard Division Suction Division	Container Division Light Engineering Div Machine Division	Big Mill Division Consolidated Mill Div
		Suction Division 11	Machine Division 12	
Large batch production	Container Division Decor Division Light Engineering Div Parts Manufacturing Div Standard Division	Decor Division Parts Manufacturing Div Standard Division 21	Container Division Light Engineering Div 22	
Process production	Big Mill Division Consolidated Mill Div			Big Mill Division Consolidated Mill Div 33

Figure 7.3 Groups of companies formed by combining technology and environment.

potential groups four of these combinations are not included in the present data. These groups which are represented are: small batch production with stagnating environment (box 11), small batch production with an increasing environment (box 12), large batch production with a stagnating environment (box 21), large batch production with an increasing environment (box 22), and finally, process production with a regulated environment (box 33).

7.5 Other factors

The only contextual factors considered as having an influence on computerized information systems in the present study are those of technology and environment. The influence of other factors cannot, however, be excluded, as they may weaken or strengthen the influence of technology and environment.

These other factors may include the size of organizations and company group affiliations. It has previously (section 7.2.10) been argued that size and company group affiliation are usually closely related and that the companies studied can all be considered as large.

Finally, some comment needs to be made in respect of variations affecting the possible impact of information technology. These can be divided into two sets of factors: information technology in general and the information technology available in an organization.

First, the development of information technology in general refers to currently available models for computer system design, computers, equipment etc as well as to the development of new models and new equipment. This development of information technology is well-known and identical to all organizations.

Second, the information technology available in an organization refers to methods and equipment currently used by the organization. This may vary between organizations. The information technology available may place restrictions on the possibilities for realizing the desired properties of a computerized information system. In this respect, it is not possible to consider the influence of technology and environment on computerized information systems to a full extent.

The factors, which refer to information technology, are not part of the subsequent analysis, they will, however, be discussed after the analysis (section 8.6).

7.6 Summary

In this chapter, the companies and their contexts have briefly been presented. The most important part of the chapter dealt, however, with forming groups of companies. This was done first with regard to technology and second with regard to environment. It was argued that the influence of technology on those computerized information systems which are related to the production system of an organization and concerned primarily with internal administrative work. Five groups of companies, combining technology and environment, were found to be included in the presented data.

These groups will be used in the next chapter (Chapter 8) in which an attempt is made to analyze the properties of computerized information systems and to relate them to the contextual factors under investigation. The analysis results in the formulation of a number of hypotheses which are then summarized in chapter 9.

8. PATTERNS OF COMPUTERIZED INFORMATION SYSTEMS

The theoretical frame of reference has been introduced in previous chapters (chapters 3, 5 and 6). In particular, the proposed framework included a model for describing computerized information systems (chapter 5).

The present chapter is the second one describing the empirical part of the study. In a previous chapter (chapter 7), the contexts of the organizations studied were presented and the companies formed into three groups, based on technology, and three groups based on environment. Although nine subgroups could in theory be formed by combining technology and environment, only five subgroups are represented in the empirical sample.

In this chapter, the characteristics of computerized information systems are considered, particularly those which are related to the technology and environment of the companies studied.

8.1 Plan of the chapter

The purpose of the chapter is to discuss and explain characteristics of the computerized information systems in relation to firstly technology and secondly environment. This will be done for each group of characteristics separately. The characteristics of a computerized information system to be evaluated are content-oriented and generic ones.

The content of each of the computerized information systems will then be described very briefly in terms of application area: purchasing, manufacturing, stock-holding, order-entry, order-statistics, invoicing and sales-statistics. It has been argued (section 5.1) that computerized manufacturing and stock-holding systems are concerned with core activities, computerized purchasing systems with input activities, and the remaining computer systems with output activities. Input and output activities together form boundary activities.

The generic characteristics of a computerized information system have previously been grouped (Figure 5.4). Each group will be discussed separately and emphasis given to major characteristics. Other characteristics will then be used to supplement the major ones. Further, some characteristics are identical across computerized information systems and companies, and they are therefore only discussed briefly.

Three aspects of complexity are considered: first, the complexity of the data base, assessed in relation to its territory; second, the variability of reports; and third, the complexity of processing operations. In addition, the time orientation of systems is assessed in terms of the frequency of

both collecting and reporting information. Although in principle it is possible to make a subdivision of the time-orientation of computerized information systems it is impractical as several characteristics concerning time orientation are closely related and can be derived from each other.

Only the major generic characteristics are presented in matrices. Other characteristics are presented in condensed form (Figure 8.1 — 8.8) and more detailed information on the computerized information systems can be found in the appendix.

Finally, some further factors that may have had an impact on the characteristics of a computerized information system are briefly discussed (section 8.6).

8.2 The complexity of the data base

The complexity of the data base has been described in terms of five characteristics. The major one is territory, which refers to the application areas of the computerized information systems in a company. The remaining four characteristics are integration, centralization, completeness and information reference and together they supplement territory. The analysis starts with the major characteristic, territory, and then more briefly considers the remaining characteristics.

8.2.1 Territory

The territories of the computerized information systems are presented in Figure 8.1. Firms belonging to the same group appear to have computerized information systems with similar territories. By first considering the influence of technology it can be seen that in small batch production the emphasis is on input-systems and core-systems, in large batch production on core-systems and output-systems, and finally, in process production on input-systems and core-systems. The territories are apparently similar in small batch production and process production.

The small batch production group consists of two engineering companies, Suction Division and Machine Division. They manufacture specialized products in short series made according to customer specifications. Production must be flexible and is characterized by frequent changes. This has two important implications. First production actions and methods cannot be completely specified well in advance. This implies a high degree of uncertainty which cannot be dealt with by production system designers (process engineers). It is therefore necessary with a relatively high level of information flow, the degree of formalization, however, is low, on account of frequent changes. Second, production needs to have a reliable supply of parts and raw materials, since a single missing part can delay or stop the complex process of assembling a product. It is therefore very important that the statuses and stocklevels of all parts and raw materials are known, in order that missing parts may be ordered well in advance. Examples of computerized information systems for solving these tasks include purchasing and stock-holding. In Machine Division, the computerized purchasing system provides information on parts that need to be replenished, and on orders to suppliers. Furthermore the computerized stock-holding system is used to provide information on stock-levels.

The use of output-systems is limited in the small batch production group. Production of specialized products in small batches is based on firm orders. Selling a product is accomplished and finished before manufacturing the product. Hence, sales orders are known before production is finished.

The large batch production group consists of five companies, belonging to different industries. They manufacture standard and specialized products in large series, producing for stock as well as on order. Production equipment is specialized and capital investments are higher than in small batch production. It is therefore essential to have a high level of efficiency in production, including a high utilization of equipment. This has important implications. Production needs to mini-

	input pur- chasing	core manu- facturing	stock- holding	output order- entry	order- stat	invoic- ing	sales- stat
Small batch production, stagnating environment	X		X				
Small batch production, increasing environment	X		X	X			
Large batch production, stagnating environment			X	X	X	X	X
		X	X	X			X
		X	X				X
Large batch production, increasing environment		X	X	X			X
		X	X				
Process production, regulated environment	X X	X X	X X			X	X

Figure 8.1 Territories of computerized information systems.
(A computerized information system is marked with X.)

mize set-up costs and ordering costs, since sudden changes in production might otherwise seriously decrease efficiency. It is thus very important to know the stock-levels of products and raw-materials as well as the composition of products. The computerized information systems therefore include stock-holding systems, which provide data on stock-levels of products, and manufacturing systems, which provide data on the composition of products.

Furthermore, in large batch production efficiency of production requires that there is a steady demand for the products as well as a steady absorption of the products in the markets. This indicates the importance of information on sales and on orders. Such data are provided by the output-systems. The major computerized information systems include those for sales-statistics (in Decor Division, Parts Manufacturing Division, Standard Division and Light Engineering Division), and one for order-statistics (in Decor Division). Sales data are also included in the computerized manufacturing system, used by Container Division, for production scheduling.

There is no use of input-systems in the large batch production group. The manufacture of products in large batches involves the use of standard raw-materials, hence there are few problems in assuring a reliable supply of raw-materials, especially if there is only a limited number of raw-materials as is the case when production is characterized by an expanding material flow.

The process production group consists of two consumer goods manufacturers, Big Mill Division and Consolidated Mill Division. The product is a standard foodstuff. Production is continuous and automated. Production equipment is highly specialized. This has two important implications. First, production methods and actions can be completely specified well in advance. This implies a low degree of uncertainty, further the production process may function with a fairly limited flow of information. As the information needs are easily predicted, one will find a high degree of formalization, hence there are essential computerized information systems for manufacturing and stock-holding.

Second, the efficient operation of the production process depends on a reliable inflow of raw materials, since missing raw materials can interrupt the continuous running of the process and a restart entails considerable costs. It is, therefore very important that the supply and deliveries of raw-materials are known in advance. The computerized information systems, in Big Mill Division and Consolidated Mill Division, therefore include purchasing and manufacturing systems. The computerized purchasing system is used in planning deliveries of raw-materials in order to keep the production process continuously running.

Clearly, then, the territories of the computerized information systems are related to the requirements for flexibility and efficiency in production. The requirements for flexibility in small batch production are supported by computerized information systems consisting of input-systems. In process production, where production results are well-known, efficiency requires continuous operation and thus depends on the inflow of raw-materials, and hence support is given by input-systems and core-systems. It is therefore hypothesized that *when production requires flexibility then computerized information systems will consist of input-systems and core-systems*. When *production requires efficiency*, it is hypothesized that *computerized information systems will consist of core-systems and output-systems*. Finally, output-systems will be found when the technical core of the companies demands accurate and reliable data about sales or orders. Output-systems will not be found when sales data are known in advance of production.

The influence of environment on the territories of computerized information systems are considered next. The territories of the computerized information systems appear to encompass more types of output-systems in a stagnating environment than in an increasing or regulated environment. Further some types of computerized information systems appear to be more common in a stagnating environment than in an increasing environment.

The reasons for this are probably that in a stagnating environment companies have difficulties in attracting customers and orders, while in an increasing environment there are plenty of orders

from regular as well as new customers. In an increasing environment production resources are used to their fullest extent, while in a stagnating environment the use of resources needs to be improved. Companies in an increasing environment can act with a relatively long-term orientation, while companies in a stagnating environment react on shorter time periods, in order to adjust to changes in the environment, and the need to exploit the smallest opportunities for increased sales. This has the following important implication. In a stagnating environment, any failure in adjusting production to sales can result in a build up of unsaleable stocks of products. It is thus more important that the sales levels of all products are known by companies operating in a stagnating than those working in an increasing environment.

This is particularly the case in large batch production. In the large batch production group there are three companies, which are characterized by a stagnating environment (Decor Division, Parts Manufacturing Division and Standard Division) and there are two companies, which are characterized by an increasing environment (Container Division and Light Engineering Division).

Examples of computerized information systems include order-statistics, which reports sales on order, and sales-statistics, which reports actual sales. In the stagnating environment, all companies use computerized sales-statistics systems, while only one company in the increasing environment does.

The firms in the regulated environment are the same as those utilizing process production. In a regulated environment companies have secure markets for products as well as assured supplies of raw materials and can therefore act with a relatively long-term orientation. This diminishes the need for computerized information systems. On the other hand, the information needs are well-known and easily formalized. Only Big Mill Division has some output-systems, and these cover invoicing and sales-statistics.

The research findings suggest that the territories of the computerized information systems are related to the time orientation of companies. On the basis of the results presented here it is hypothesized that *computerized information systems encompass fewer output-systems when the environment enables the company to act with a relatively long-term orientation*. Further it is hypothesized that *computerized information systems encompass more output-systems when the environment requires companies to react and adjust production*.

8.2.2 Supplementary characteristics

Territory is only one of the characteristics proposed to describe the complexity of the data base. The other characteristics are integration, centralization, completeness and information reference and these supplement territory.

Integration of two (or more) computerized information systems implies that there is a business need for using data in several systems, for example data may belong to a common database or data from one system may be used in the next system. Centralization refers to whether a computerized information system has been designed for and is used by several divisions or whether it is especially designed for and used by one division. Completeness refers to whether all cases or all types within an information category (e.g. all transactions or invoices) are included in a computerized information system. Information reference (i.e. the states, events or processes represented) classifies information as internal or external. The findings on the four supplementing characteristics are shown in Figure 8.2 and are discussed briefly below.

Companies belonging to the same group appear to have computerized information systems with similar characteristics. In the small batch production group there are integrated and decentralized computerized information systems. (this will be considered later in connection with environmental influence). In process production there are no integrated computerized information systems and the computerized information systems are decentralized.

	Integration	Centralization	Completeness	Information reference
Suction	purchasing and stock-holding	only user	purchasing and stock-holding are partial	input: external core: internal output: external
Machine	stock-holding and order-entry	only user	all complete	input: external core: internal output: external
Decor	order-entry and invoicing	all used by all divisions	all complete	core: internal output: external
Parts Manufacturing	stock-holding and order-entry	all used by some divisions	order-entry is partial	core: internal output: external
Standard	...	only user	all complete	core: internal output: external
Container	...	only user	all complete	core: external, internal output: external
Light Engineering	...	only user of manufacturing and stock-holding, sales statistics used by other divisions	all complete	manufact: external, internal stock-hold: internal output: external
Big Mill	...	only user	stock-holding and output are partial	input: external manufact: external stock-hold: internal output: external
Consolidated Mill	...	only user	all complete	input: external manufact: external stock-hold: internal

Figure 8.2 Complexity of the data base

Clearly, integration and centralization are related to requirements for flexibility and efficiency. The requirements for flexibility in small batch production are supported by integrated and decentralized computerized information systems. The requirements for efficiency in large batch production mean that more computerized information systems are integrated and centralized.

Hence, it is hypothesized that *computerized information systems are integrated and decentralized when production requires flexibility*. Further, it is hypothesized that *more computerized information systems are integrated and centralized when production requires efficiency*.

Organizations in a stagnating environment have computerized information systems that are integrated and centralized. Those in an increasing or regulated environment have computerized information systems that are decentralized but not integrated. In a stagnating environment, core-systems contain only internal information. However, in both increasing and regulated environments some core-systems include external as well as internal information.

Examples of core-systems which include external information are the computerized manufacturing systems used by Big Mill Division and Consolidated Mill Division. These provide information on the amount of raw material available from each supplier are used in planning deliveries of raw materials. Another example is the computerized manufacturing system used by Container Division, in which external data on customer consumption are used in forecasting customer orders for all products during a three months period.

It appears the requirements to react and adjust in a stagnating environment are supported by integrated and centralized computerized information systems. Those organizations which can act with a relatively long-term orientation are supported by non-integrated and decentralized computerized information systems, in which core-systems contain external as well as internal data.

Hence, it is hypothesized that *computerized information systems are integrated and centralized when the environment requires companies to react and adjust*. Further, it is hypothesized that *computerized information systems are non-integrated and decentralized when companies are able to act with a relatively long-term orientation*.

8.3 The complexity of reports

Three characteristics have been proposed to describe the complexity of reports. The major ones are variability and value reference. Variability refers to whether reports are fixed or variable. When reports are variable it is possible to vary the factors considered or the degree of detail as for example in those reports which may present data on all products (customers) or only on some. Value reference refers to whether data in a report are forecasted or historical/actual. Figure 8.3 presents the findings on variability and value reference of computerized information systems.

In small batch production there are only fixed reports, with reports from input systems containing forecasted as well as actual data. In large batch production the core-systems produce only fixed reports whereas the output-systems produce fixed, and variable reports. The reports from core-systems contain forecasted as well as actual data, while those from output-systems contain only actual data. In process production all reports are fixed and contain forecasted as well as actual data.

Small batch production is characterized by flexibility and frequent changes. As already observed, reliable supply of part and raw materials is necessary, since a single missing part can halt the complex process of assembling a product. It is, thus very important that parts are replenished and forecasted needs for parts are known. It is also important that there is a match between forecasted and actual needs for in they are not, parts may be missing. Examples of computerized information systems include the computerized purchasing systems in Suction Division and Machine Division. In both companies, the computerized purchasing systems provide reports on parts or components that need to be replenished, as well as reports on actual deliveries from all suppliers.

	Input pur- chasing	core manu- facturing	stock- holding	output order- entry	order- statistics	invoic- ing	sales- statistics
Suction	<u> </u> <u> </u>		<u> </u> <u> </u>				
Machine	<u> </u> <u> </u>		<u> </u> <u> </u>	<u> </u> <u> </u>			
Decor			<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>
Parts Manufacturing		<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>
Standard		<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>
Container		<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>			
Light Engineering		<u> </u> <u> </u>	<u> </u> <u> </u>				<u> </u> <u> </u>
Big Mill	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>			<u> </u> <u> </u>	<u> </u> <u> </u>
Consolidated Mill	<u> </u> <u> </u>	<u> </u> <u> </u>	<u> </u> <u> </u>			<u> </u> <u> </u>	<u> </u> <u> </u>

Figure 8.3 Complexity of reports: variability; |||| in order: fixed, package, variable reports.

|||| available

and value reference: |||| in order: forecasted and actual data.

|||| available

In large batch production a high degree of efficiency and a steady absorption of products in the markets are essential. Efficiency in production is affected by set-ups, which therefore need to be minimized. Production scheduling is based on forecasts of the need for products. It is again very important that there is a match between the forecast and actual needs for products in order to avoid building up stocks of slow-selling products. An example of a computerized information system producing reports containing both forecasted and actual information is the manufacturing system used by Container Division. This system contains a model for forecasting customer orders for a three months period and acts as a basis for production scheduling. Another example is the computerized stock-holding system in Decor Division, in which reports contain actual stock-levels and transactions as well as forecasted levels and needs.

Process production is characterized by continuous and automated production. The efficient operation of the production process depends on a reliable inflow of raw materials. Forecasted information is important in scheduling the inflow of raw materials. Examples here are the computerized purchasing and manufacturing systems in Big Mill Division and Consolidated Mill Division. The purchasing system is used in acquiring raw-materials, based on forecasted supplies, but also in the resulting transactions based on actual supplies. The manufacturing system is used in scheduling deliveries, based on forecasted data, and in reporting actual deliveries.

The findings suggest that whether computerized information systems contain actual as well as forecasted data is related to requirements for flexibility and efficiency. The requirements for flexibility in small batch production are supported by forecasted and actual data in the input-systems. The need for efficiency in large batch production is supported by forecasted and actual data in core-systems. Finally, the need for efficiency in process production requires forecasted and actual data in both input-systems and core-systems.

Hence, it is hypothesized that *input-systems contain forecasted data when production requires flexibility*. Further, it is hypothesized that *core-systems contain forecasted data when production requires efficiency*.

Attention is now given to the influence of the environment. The findings here suggest that when the environment is stagnating, companies appear to have variable and package reports in addition to the fixed reports. On the other hand, only fixed reports were found in those companies operating in increasing environments.

In a stagnating environment, companies need to react and make adjustments on a short term basis. To be efficient, such adjustments need to be focused on limited areas, such as particular products or customers. Hence reports which contain, in varying degrees of detail, data concerning these limited areas are essential. Examples of computerized information systems which produce variable or packaged reports are the order-statistics system (in Decor Division), and the sales-statistics systems (in Decor Division, Parts Manufacturing Division, and Standard Division). In these systems reports may vary in terms of partitioning and degree of detail of the data presented and also for how long they are produced (cf life-time of report-type).

It appears that the variability of reports is related to the time orientation of companies. In order to improve their performance in a stagnating environment, companies attempt to obtain as much information as possible from computerized information systems. One way of increasing the productivity of computer systems is to invest in variable reports. The increased use of variable reports is intended to support the need of such companies to react on a short-term basis.

Hence, it is hypothesized that *variable reports are more likely to be produced by computerized information systems in a stagnating environment*.

Mode of presentation	only tabular formats are used
----------------------	-------------------------------

Figure 8.4 Complexity of reports.

Finally, the one remaining characteristic of complexity is mode of presentation. This concerns how data are presented in a report, especially whether a tabular format or some other format is used. However, only reports having tabular formats were found in the nine companies studied (Figure 8.4).

8.4 The complexity of processing

Two characteristics have been proposed to describe the complexity of processing: operations and program origin. The most important of these is operations, a term referring to manipulations that are performed on data. The analysis has been restricted to a consideration of processing operations and the findings of the study are presented in Figure 8.5.

First updating and aggregating operations were found in all of the computerized information systems. These two operations may be considered as fundamental and necessary for the functioning of a computerized information system. The findings concerning the other three operations (searching, transposing and inferring) are more complex. However, though searching was not observed in this study, this operation is nevertheless necessary when computerized information systems have query-facilities.

In small batch production, complex operations are used in only a few computer systems, specifically transposing in input-systems and inferring in core-systems. In large batch production, transposing and inferring are used in a greater number of computer systems, inferring in core-systems and transposing in output-systems. In process production the use of transposing and inferring operations is limited.

Not only is small batch production flexible and characterized by frequent changes, but also a reliable supply of parts and raw materials is essential. It is thus very important that the statuses and stock-levels of all parts and raw-materials are known. Further, to know which parts need to be replenished presumes that re-order-points and order-quantities can be computed, and this involves inferring operations. An example of this is the computation of re-order points and order-quantities for all parts using the simple Wilson-model which was included in the computerized stock-holding system used by Machine Division.

Large batch production requires efficiency, a steady absorption of products, and a minimum of set-up costs. It is thus very important that stock-levels are known and that re-order points and order-quantities can be determined, in order to reduce the number of set-ups. It is further very important to know sales on order and actual sales, and to be able to present data with varying degrees of detail and in different combinations. An example of an inferring operation is the Wilson-model used to compute re-order points and order-quantities in the computerized stock-holding system in Decor Division. Another example is the parts explosion used to derive the parts and raw materials required to produce a finished product, in the computerized manufacturing system in Parts Manufacturing Division. Examples of transposing operations are found in the computerized sales-statistics and order-statistics systems in Decor Division and Parts Manufacturing Division and mean that data can be presented with different degrees of detail, and with different main variables (for example the same data may presented with either the product, or the customer as the main variable).

In process production, the efficient operation of the production system requires a steady inflow of raw materials. It is thus important to know the supply of raw materials in advance and to find the best combination of suppliers. Examples of inferring operations are found in Consolidated

	input pur- chasing	core manu- facturing	stock- holding	output order- entry	order- statistics	invo- icing	sales- statistics
Suction	   		   				
Machine	   		   	   			
Decor			   	   	   	   	   
Parts Manufacturing		   	   	   			   
Standard		   	   	   			   
Container		   	   	   			   
Light Engineering		   	   	   			   
Big Mill	   	   	   			   	   
Consolidated Mill	   	   	   			   	   

Figure 8.5. Complexity of processing: operations  in order: up-dating, aggregating, searching, transposing, and inferring operations.
 major operations,  supplementary operation.

Mill Division. The computerized purchasing system is used in testing and checking alternative combinations of suppliers of the raw material and the computerized stock-holding system is used in testing and checking alternative stocking-plans.

The findings suggest that the use of transposing and inferring operations in computerized information systems is related to requirements for flexibility and efficiency in production. The requirements for flexibility in small batch production are supported by a limited use of transposing and inferring operations in input-systems and core-systems. Efficiency in large batch production is supported by a considerable use of transposing and inferring operations in core-systems and output-systems. Finally, in process production where production results are well-known, there is only limited use of inferring operations.

Hence, it is hypothesized that *the use of complex operations in computerized information systems will be more important when production requires efficiency than when it requires flexibility.*

The influence of environment on transposing and inferring operations is considered next. In those companies operating in a stagnating environment, both transposing and inferring operations are used. In an increasing environment, only inferring operations appear to be used. This is particularly clear in the case of large batch production.

Companies in an increasing environment can act with a relatively long-term orientation, while companies in a stagnating environment react and adjust on a short-term basis. It is thus important in a stagnating environment, to be able to analyze sales results, and this requires access to different types of operations. Examples from the study include the use of transposing and inferring operations in computerized information systems in Decor Division and Parts Manufacturing Division.

In an increasing environment it is important to be able to forecast production, and this requires access to inferring operations or models, which may be simple ones or complex OR-models. An example from the study is the use of inferring operations in Container Division's computerized manufacturing system which involves forecasting customer orders for the next three months. Another example was found in Light Engineering Division's computerized manufacturing system, in which a parts explosion is used.

Evidently, the use of transposing or inferring operations in computer systems is related to the requirements to react with a short-term orientation. The use of these operations also depends on the degree to which it is possible to act with a relatively long-term orientation. The need to react with a short-term orientation in a stagnating environment is supported by the use of both transposing and inferring operations. The relatively long-term orientation of actions in an increasing environment is supported by the use of inferring operations.

Hence, it is hypothesized that *both transposing and inferring operations will be used in stagnating environments.* Further, it is hypothesized that *only inferring operations will be used in an increasing environment.*

There is one remaining characteristic of the complexity of processing. This is program origin, which concerns whether a program, especially an application program, has been designed by system designers in the company or acquired from some external supplier, such as a computer manufacturer or software house. However, in the companies studied all application programs originated within the company, i.e. they have been designed within the companies (Figure 8.6).

Program origin	all application programs in all companies, had been designed within the companies
----------------	---

Figure 8.6 Complexity of processing

8.5 Time orientation

A total of nine characteristics have been proposed to describe the time orientation of a computerized information system. (Figure 5.4). The major ones are frequency of collecting and frequency of reporting and the analysis will start with these. The remaining characteristics will then be considered separately, as they do not add anything of significance.

8.5.1 Frequencies

The analysis will deal exclusively with the frequency of collecting and frequency of reporting. These refer respectively to how often data are collected and reported. Figure 8.7 presents the findings on the frequency of collecting, and Figure 8.8 presents the findings on the frequency of reporting. The frequency of collecting and reporting are usually identical in the presented data. There are, however, a number of cases in which the frequency of reporting differ from the frequency of collecting. As a result data collected may be described with several frequencies.

Companies belonging to the same group appear to have similar frequencies for both collection and reporting. In small batch production the number of frequencies is small, and they all occur at narrow intervals; most computerized information systems have only one frequency for collecting and one for reporting. In large batch production information is collected and reported on a more frequent and varied basis. Several computerized information systems have more than one frequency for collecting as well as for reporting. Continuous frequencies are found only in large batch production. In process production there are only a small number of frequencies, all within narrow intervals, and data are collected or reported with longer intervals than in small batch or large batch production.

Small batch production involves manufacturing specialized products in short series according to customer specifications. Production is flexible and characterized by frequent changes. These factors have two significant implications. First, production actions and methods cannot be completely specified in advance. This means that large amounts of uncertainty must be handled thus there is a high level of information flow, together with a low degree of formalization. Second, production is dependent on a reliable supply of parts and raw materials, since a single missing part can halt the complex process of assembling a product. It is thus, very important to have timely and regular information on stock levels and replenishment needs. For example, in Machine Division the computerized stock-holding system collects stock-transactions and reports stock-levels daily; other data are reported less frequently, for example replenishment needs once a week. The computerized purchasing system, in Machine Division collects data such as orders to suppliers daily but presents data both daily and monthly, for example compilations of current or outstanding orders to suppliers.

Large batch production involves manufacturing standard and specialized products in large series for stock as well as to order. Production equipment is specialized. Production requires efficiency and a steady demand for products. Sudden or spontaneous changes in production can have disastrous effects on efficiency. It is thus important to have current information on stock-levels and sales. For example, in Parts Manufacturing Division stock-transactions are collected continuously in the computerized stock-holding system, and stock-levels are reported continuously and daily. In the computerized stock-holding system in Decor Division most data are collected with a single frequency (daily) but reports are presented with various frequencies. The sales-statistics systems collect and report data monthly. However additional data may be aggregated to provide comparisons over longer time periods.

Process production involves producing a standard consumer good. The limits of production are known. Production is continuous and highly automated. These features have two important implications. First production methods and actions can be completely specified. This means that little uncertainty needs to be handled, thus there is a limited information flow but a high degree of

	input pur- chasing	core manu- facturing	stock- holding	output order- entry	order- statistics	invo- icing	sales- statistics
Suction							
Machine							
Decor							
Parts Manufacturing							
Standard							
Container Light Engineering							
Big Mill Consolidated Mill	 	 	 				

Figure 8.7. Time orientation: frequency of collecting.
 ||||| in order: continuous, one or two days, week, two weeks or month, longer than month.
 |||| major frequency, |||| supplementary frequency

	input pur- chasing	core manu- facturing	stock- holding	output order- entry	order- statistics	invo- icing	sales- statistics
Suction	   		   				
Machine	   		   	   			
Decor Parts Manufacturing Standard		           	       	       	       	       	       
Container Light Engineering		       	       	   			   
Big Mill Consolidated Mill	       	       	       			       	       

Figure 8.8 Time orientation: frequency of reporting.

 in order: continuous, one or two days, week, two weeks or month, longer than month.

 major frequency,  supplementary frequency

formalization. Second, the efficient operation of the production process depends on a reliable inflow of raw materials, since missing materials can interrupt the continuous running of the production system. It is thus important to know and report the availability and supply of raw materials during a period of time. The frequencies used are mainly weekly, for example the computerized manufacturing system involves scheduling deliveries of raw materials a few times each year although actual deliveries are reported weekly. More frequent reports will probably not provide any significant information as long as there is a steady inflow of raw materials. In testing and simulating alternative deliveries of raw materials, the computerized purchasing system in Consolidated Mill Division may be used daily or every second day.

Clearly, the frequencies of the computerized information systems are related to the requirements for flexibility and efficiency in production. The requirements for flexibility in small batch production are supported by few flexibility in small batch production are supported by several frequencies, continuous as well as others. In process production weekly frequencies are sufficient to obtain efficiency.

Hence, it is hypothesized that *computerized information systems will have a limited number of frequencies when production requires flexibility*. Further, it is hypothesized that *computerized information systems will have a large number of frequencies, including continuous ones, when production requires efficiency*.

The influence of environment on the frequencies of computerized information systems is considered next. Continuous frequencies appear to be more common in a stagnating environment than in an increasing environment. This seems to be particularly the case in large batch production.

In an increasing environment business is good and companies can act with a relatively long-term orientation. It is thus sufficient to collect and report data relatively infrequently. Continuous collecting and reporting are not essential. Thus, for example, the computerized manufacturing system used in Container Division collects data daily and weekly and reports weekly and monthly. The monthly reports have a period reference of three months.

In a stagnating environment, companies have difficulties in attracting customers and orders. They react and adjust on a short-term basis. Accordingly it is important to collect and report information more frequently. There are several examples of continuous data collection and reporting in the computer systems studied in this project. These include the stock-holding system in Parts Manufacturing Division, the order-entry systems in Decor Division and Parts Manufacturing Division, and the invoicing system in Decor Division. Several frequencies were also observed in other computer systems, for example the order-statistics system in Decor Division allows a choice between weekly and monthly frequencies.

It appears that, the frequencies of the computerized information systems are related to the time orientation of companies. The need to react and adjust in a stagnating environment is supported by frequent reporting covering short intervals. The ability to act with a long-term orientation in an increasing environment allows relatively longer frequencies.

The stagnating environment has previously (Figure 7.2) been characterized as the most changing, complex and hostile, relative to the other two types of environment. Gordon and Miller (1976) argue that frequencies are more crucial in a dynamic than in an unchanging environment, and that as hostility increases further reports need to be more frequent.

Hence, it is hypothesized that *computerized information systems will have few frequencies when the environment allows a company to act with a long-term orientation*. Further, it is hypothesized that *computerized information systems will have several frequencies, including continuous and monthly or longer, when the environment requires a company to react and adjust on a short-term basis*.

8.5.2 Other characteristics of time orientation

In addition to the frequency of collecting and reporting data, the time-orientation of a computer system can be described in terms of a further seven characteristics which are discussed briefly below.

Among the remaining characteristics are four delays: collection, distribution, processing and ordering delay. Ordering delay refers to the time taken from ordering until receiving a report. Together collecting delay, distribution delay and processing delay account for the time from the occurrence of an event until a report is distributed to a user. These delays can, in many cases, be derived from the frequencies. There is very little variation between companies with regard to the delays. Usually reports are available to users the day after being produced although longer delays may occur. For example reports from the sales-statistics system are available two weeks after the end of the reference period in Standard Division, and after one month in Parts Manufacturing Division.

The last three characteristics of time orientation are: the period reference, storage period and the life-time of the report type.

Period reference refers to the period covered by a report and may represent a past or future period. Historical data, whether they be actual or forecasted, concern a past period; data which forecast events yet to happen concern a future period. The length of the period-reference usually corresponds with the frequencies for collecting and reporting data although deviations may occur. For example, the period-reference may be considerably longer than the frequencies as is the case in the computerized manufacturing system in Container Division, where customer orders are forecasted monthly three months ahead.

The storage period refers to the period during which data are stored and it is usually related to the period reference. The main exceptions to this pattern are the computerized information systems for order-statistics and for sales-statistics, in which data can be stored for longer periods in order to make possible comparisons with data from previous months.

The life-time of report-type is only interest in connection with variable reports for which the user may prescribe a time-period during which a report is to be produced. Variable reports are produced only by the computerized information systems for order-statistics and sales-statistics in Decor Division and Parts Manufacturing Division.

8.6 Other factors

In the analysis in the previous sections (section 8.2 - 8.5) the characteristics of computerized information systems have been considered as contingent on the technology and the environment of an organization. The possible impact of information technology will now be considered and can be divided into two sets of factors: first the development of information technology in general, and second the information technology available in an organization.

General information technology refers to information technology currently available and comprises the models and methods of system design, computers and equipment provided by research organizations or equipment suppliers. The development of information technology, which is common to all organizations, has produced an increasing supply of new methods and new equipment which have resulted in improved performance, shorter processing-times and lower costs per transaction.

The current stage of development places a number of limits on the possibilities for using computers. For example, the context of an organization may have some features which makes it necessary for the organization to have computerized systems with particular characteristics. At the same time, however, there may be no computer available with the capacity to meet these requirements. As the development of information technology progresses, it will be possible to

develop computer systems with a wider range of characteristics. In this way, it should be possible to obtain a higher degree of 'fit' between the demands of the contextual factors, environment and technology, and the characteristics of computerized information systems. For example it may be possible to have more variability, several modes of presentation, and more kinds of operations. As the development of information technology continues, it is possible that the differences between computer systems in different organizations will increase, since it will be easier to design systems with the desired characteristics.

There are, however, a number of other reasons why the information technology available in an organization may fall short of the information technology available in general, limiting thereby its potential for achieving the desired system characteristics. These include the relative success of previous applications of computer systems and the strategies for computer system design. It seems likely that the earlier an organization started to design computerized information systems, the more knowledge it has about systems design and computer systems and, consequently, the more likely it is to have the computerized information systems with the characteristics it requires.

The companies studied differ with regard to both the information technology they have available and when they started to use computers. These variations in the available information technology account, in part for the lack of consistency in the hypotheses forwarded.

In addition to information technology, there are other reasons why the desired characteristics of computerized information systems are not always realized. These include the existence of company groups and the restrictions they may impose on computerized information systems, for example, in respect of decentralization. In order to be able to use the specialized resources within a company group, there are usually strong requirements for standardization. In this way, computerized information systems may be transferred from one company to another within the group. As a result, an individual company may have imposed upon it a computerized information system which meets the overall requirements of the company group but which differs from the characteristics required by the particular company. This factor may help in explaining why the results depart from those predicted.

The companies studied are all part of larger company groups. This may account for some variations from the hypothesised relationships and lack of consistency in some of findings. However, future developments in information technology may diminish the importance of company group influence and increase the potential for tailoring computerized information systems to contextual requirements of individual companies within larger groups.

8.7 Conclusions

The basic hypothesis introduced at the start of this thesis (section 1.3) argued that different organizations have different computerized information systems and that these differences could, to some extent, be explained by differences in organizational context. After a review of the existing theoretical and empirical evidence (chapter 4), this chapter has further explored the fundamental hypothesis. The characteristics of computerized information systems have been related to the contextual factors technology and environment and a number of more detailed hypotheses have been formulated and given empirical support. The detailed hypotheses are summarized in chapter 9.

9. SUMMARY AND CONCLUSIONS

In this chapter the different threads of the previous chapters are brought together. The study and the main results obtained are summarized. Finally some implications for the design of computerized information systems are presented. The main thesis is that a contingency approach to the design of computerized information systems is a supplementary model to the existing approaches or methodologies for designing computerized information systems.

The focus of the study was those computerized information systems which support the production system in an organization; the overall purpose was to relate the characteristics of computerized information systems to two contextual factors, technology and environment.

9.1 Framework

It has been demonstrated that contextual factors are important variables for understanding the structure of complex organizations (Burns & Stalker 1966, Lawrence & Lorsch 1967, Perrow 1970, Thompson 1967, Woodward 1965). Hence it was suggested that the computerized information systems in an organization are similarly contingent on contextual factors.

9.1.1 *Determining factors*

The main contextual factors which have been identified as having an impact on computerized information systems are organizational environment and technology. With regard to size it was argued that the companies described in this study could all be considered as large.

Reviewing the research work which uses a contingency approach, it was noted that environment, technology and task are not always clearly distinguished, differentiated or separated. Lawrence and Lorsch (1967), for example include technology in environment. Woodward (1965) uses the physical flow of production and Thompson (1967) uses interdependence as a property of technology. These could equally well be considered as properties of the task.

The conceptualization and definitions of both the environment and technology differ among students of organizations. These variations can be seen to depend on such factors as on the part of the organization to which the concept refers and the level or unit of analysis adopted (individual, group or organizational). Furthermore, technology has both a hardware aspect (tools, equipment etc) and a software one (working methods etc). Environment has been conceptualized at both an

individual and group level, for example with reference to decision-centers (Duncan 1972), and at an organizational level (Lawrence & Lorsch 1967). Technology likewise has been conceptualized at both individual or group levels for example in terms of the work-situation (Perrow 1970) and at the organizational level (Thompson 1967, Woodward 1965). Woodward (1965, 1970) refers on different occasions to technology as having either a hardware or a software aspect but also as a mixture of the two (technical complexity refers exclusively to the hardware aspect).

In the study reported, environment and technology are treated as distinct factors, having separate and independent effects on organizations and computerized information systems. However it is assumed that their impact will affect different organizational levels. It was argued that technology has the primary impact on computerized information systems, the impact of environment being supplementary.

In the research reported here technology has been defined and described in a way closely akin to that of Woodward (1965). Environment has been defined in terms of four dimensions: changeability, complexity, hostility and restrictiveness. Based on the empirical findings, three groups of technology and three groups of environment were identified. The groups of technology identified are: small batch production, large batch production and process production. The environment is classified according to whether it is stagnating, increasing or regulated. Furthermore, it should be noted that the groups of companies identified are based on relative differences between companies, hence they do not signify any absolute classification.

9.1.2 Determined factors

The generic characteristics of computerized information systems are particularly important when considering the impact of contextual factors. Another group, the content-oriented characteristics, are directed towards application areas, while generic characteristics are directed towards the structural and functional attributes of computerized information systems. For the purposes of the present study, it was argued that generic models are the most important.

In the present study, the content of computer systems has been indicated very briefly and only in terms of application areas covered: i.e. purchasing, manufacturing, stock-holding, order-entry, order-statistics, invoicing and sales-statistics. With reference to the distinction between technical core and boundary activities (Thompson 1967) it was argued that input-systems include purchasing, core-systems include manufacturing and stock-holding, and finally, output-systems include the remaining application areas.

In reviewing the existing generic models of computerized information systems a number of difficulties were found. Some models refer to information systems in general (e.g. Galbraith 1973); others deal only with accounting systems (e.g. Ginzberg 1980, Gordon & Miller 1976), while others refer to computerized information systems (e.g. Alter 1977, Bjørn-Andersen 1974). However, the majority of generic models have not taken contextual factors into account to any significant extent.

A model for describing the generic characteristics of computerized information systems was therefore proposed. The characteristics of a computerized information system were classified *first* in terms of their data base, reports and processing procedures. The data base comprises the processes for collecting and storing data; reports cover the presentation of data; and processing includes all those activities concerned with the manipulation of the data. *Second*, system characteristics were classified in terms of their complexity and time orientation.

The classification-schemes were used to cross-classify the characteristics of computerized information systems resulting in the identification of six groups of characteristics. Time-orientation may, however, be treated as a single group. In analysing computerized information systems, four groups of characteristics have been presented: the complexity of the data base, the complexity of reports, the complexity of processing, and time orientation.

9.2 Relationships between context and computerized information systems

The results of the research on the impact on computerized information systems of the organizational context are summarized in this and the following section.

The research has been based on the proposition that organizations seek to tailor their computerized information systems to their organizational context. Hence, differences between computerized information systems can be explained by differences in organizational contexts. In this section, hypotheses focussing on the characteristics of computerized information systems are presented, and in the next section hypotheses focussing on the impact of technology and environment are presented. The hypotheses are shown in Figures 9.1 - 9.3.

9.2.1 The complexity of the data base

Territory is the major characteristic which describes the complexity of the data base. Territory refers to the application areas of the computerized information systems in an organization.

Differentiating the companies on the basis of technology, we found the emphasis in small batch production to be on input-systems and core-systems, in large batch production on core-systems and output-systems, and finally, in process production on input-systems and core-systems.

Hence, *when an organization's production requires flexibility*, as in small batch production, it is hypothesized that *computerized information systems will focus on input-systems and core-systems*. Further, *when its production requires efficiency*, as in large batch production, it is hypothesized that *computerized information systems will focus on core-systems and output-systems*. (Hypotheses S1, L1 and P1).

As regards the influence of environment, the findings can be summarised as follows: the territories of computerized information systems appear to encompass more types of output-systems in companies operating in a stagnating environment than in those having an increasing or regulated environment. Further, some types of computerized information systems appear to be more common in a stagnating environment than in an increasing environment.

Hence, *when the environment enables the company to act with a relatively long-term orientation*, as in an increasing environment, it is hypothesized that *computerized information systems will encompass fewer output-systems*. Further, in a stagnating environment *since companies are required to react and adjust on a short-term basis* and to exploit the smallest opportunities for increased sales, then it is hypothesized that *computerized information systems will encompass more output-systems*. (Hypotheses L1.1 and L1.2)

Another four characteristics which supplement territory, as attributes of data base complexity are *integration, centralization, completeness and information reference*.

The following variations were observed in companies having different technologies: In small batch production computerized information systems were *integrated* and *decentralized*. In large batch production the computerized information systems were integrated systems and there were centralized as well as decentralized systems. In process production, there were no integrated computerized information systems, and the information systems were decentralized.

Hence, *when production requires flexibility*, it is hypothesized that *computerized information systems will be integrated and decentralized*. Further, *when production requires efficiency* it is hypothesized that *more computerized information systems will be integrated and centralized*. (Hypotheses S2, L2 And P2).

Environmental variations were associated with the following pattern of system characteristics. Computerized information systems were integrated and centralized in a stagnating environment

No	Hypotheses
S1	The <i>territory</i> of computerized information systems will focus on input-systems and core-systems.
S2	Computerized information systems will be <i>integrated</i> and <i>decentralized</i> .
S3	Input-systems will contain <i>forecasted</i> data besides actual data.
S4	Transposing and inferring <i>operations</i> will be used to a small extent in processing data.
S5	Computerized information systems will have a limited number of <i>frequencies</i> for collecting as well as for reporting. Frequencies will be daily or weekly.

Figure 9.1 Relationships between small batch production and computerized information systems

but decentralized and non-integrated in increasing or regulated environments. Whereas in a stagnating environment, core-systems contained only internal information, in increasing and regulated environments core-systems included external as well as internal information.

Hence, when the *environment requires that companies react and adjust*, it is hypothesized that *computerized information systems will be integrated and centralized*. Further, when *companies are able to act with a relatively long-term orientation*, it is hypothesized that *computerized information systems will be non-integrated and decentralized*. (Hypotheses L2.1 and L2.2).

9.2.2 The complexity of reports

Variability and *value reference* were identified as the major characteristics of report complexity.

The following variations were observed in companies having different technologies: In small batch production, there were only fixed reports, and reports from the input-systems contained both forecasted and actual information. In large batch production, there were only fixed reports from core-systems, but fixed, packaged as well as variable reports from output-systems; reports from core-systems contained forecasted as well as actual information, while those from output-systems provided only actual data. In process production, there were again only fixed reports, with reports from the input- and core-systems containing forecasted as well as actual information.

Hence, when *production requires flexibility* it is hypothesized that *reports from input-systems will contain forecasted information*. Further, when *production requires efficiency*, it is hypothesized that *reports from core-systems will contain forecasted data*. It is hypothesized that *there will be more variable reports, when production requires efficiency than when it requires flexibility*. (Hypotheses S3, L3 and P3).

No	Hypotheses
L1	The <i>territory</i> of computerized information systems will focus on core-systems and output-systems.
L1.1	In an <i>increasing</i> environment the territory of computerized information systems will encompass a small number of output-systems.
L1.2	In a <i>stagnating</i> environment the territory of computerized information systems will encompass several output-systems.
L2	More computerized information systems will be <i>integrated</i> and <i>centralized</i> .
L2.1	In an <i>increasing</i> environment computerized information systems will be non-integrated and decentralized.
L2.2	In a <i>stagnating</i> environment computerized information systems will be integrated and centralized.
L3	Core-systems will contain <i>forecasted</i> data besides actual data, and reports will be <i>variable</i> .
L3.1	In an increasing environment, reports will be <i>fixed</i> .
L3.2	In an <i>stagnating</i> environment <i>variable</i> reports will be more likely to be produced.
L4	Transposing and inferring <i>operations</i> will be used in processing data.
L4.1	In an <i>increasing</i> environment only inferring operations will be used.
L4.2	In a <i>stagnating</i> environment transposing and inferring operations will be used.
L5	Computerized information systems will have a large number of <i>frequencies</i> for collecting as well as for reporting.
L5.1	In an <i>increasing</i> environment the number of frequencies will be small.
L5.2	In a <i>stagnating</i> environment there will be several frequencies. Frequencies will range from continuous to monthly.

Figure 9.2 Relationships between large batch production and computerized information systems.

No	Hypotheses
P1	The <i>territory</i> of computerized information systems will focus on input-systems and core-systems.
P2	Computerized information systems will be <i>non-integrated</i> and <i>decentralized</i> .
P3	Input-systems and core-systems will contain <i>forecasted</i> data besides actual data.
P4	Inferring <i>operations</i> will be used to a very small degree.
P5	Computerized information systems will have a limited number of <i>frequencies</i> for collecting as well as for reporting. Frequencies will be mainly weekly.

Figure 9.3 Relationships between process production and computerized information systems.

The following environmental variations were observed. Organizations operating in a stagnating environment had variable, packaged and fixed reports while those working in an increasing environment had only fixed report.

Hence, *when companies need to react and adjust with a short-term orientation*, i.e. in a stagnating environment, where it is hard to maintain the present level of operations, it is hypothesized that *variable reports are more likely to be produced*. Further, *when companies can act with a relatively long term orientation*, as in an increasing environment, *reports are fixed*. (Hypotheses L3.1 and L3.2).

9.2.3 The complexity of processing

Operations are the major component characterising the complexity of processing. Updating and aggregation are fundamental and necessary operations and they are found in all computerized information systems.

The following relationships were found with technology: In small batch production, transposing is used in input-systems and inferring in core-systems. In large batch production transposing and inferring are used in a greater proportion of computerized information systems, with inferring dominating in core-systems and transposing dominating in output-systems. In process production, the use of transposing and inferring operations are limited.

Hence, it is hypothesized that the *use of transposing and inferring operations* in computerized information systems will be *more important when production requires efficiency than when it requires flexibility*. (Hypotheses S4, L4 and P4).

The findings with regard to the influence of environment were as follows: In stagnating environ-

ments both transposing and inferring operations are used whereas in an increasing environment only inferring operations appear to be used.

Hence, when the *time-perspective of companies is short* as in a stagnating environment, it is hypothesized that *both transposing and inferring operations will be used*. Further, when the *time-perspective of companies is relatively long*, as in an increasing environment, it is hypothesized that *just inferring operations will be used*. (Hypotheses L4.1 and L4.2)

9.2.4 Time orientation

The major characteristics defining the time orientation of a system are the *frequency of collection* and *frequency of reporting*.

The following relationships with technology were observed: In small batch production, most computerized information systems have only one frequency for collecting and one for reporting. In large batch production, there are a larger number of frequencies, which further form a broad range. Several computerized information systems have more than one frequency for collecting or reporting. Continuous frequencies are only found in large batch production. In process production, there are only a small number of frequencies, which form a limited range, and data are collected or reported with longer intervals than in small batch or large batch production.

Hence, when *production requires flexibility* it is hypothesized that *computerized information systems will have a limited number of frequencies*. Further, when *production requires efficiency*, it is hypothesized that *computerized information systems will have a large number of frequencies*, forming a broad range, including continuous. (Hypotheses S5, L5 and P5).

Considering environment, continuous frequencies were found to be more common in a stagnating environment than in an increasing environment.

Hence, it is hypothesized that *computerized information systems will have few frequencies when the environment allows a company to act with a long-term orientation*. Further, it is hypothesized that *computerized information systems will have several frequencies*, including continuous and monthly or longer, when *the environment requires a company to react and adjust on a short-term basis*. (Hypotheses L5.1 and L5.2).

9.3 Contextual influence

The characteristics of computerized information systems were the main focus of the previous section. The contextual factors, technology and environment, are the focus of this section. Since it has previously (chapter 7) been argued that technology has the primary impact, while environment is only supplementary, technology will be considered first and environment next.

9.3.1 Impact of technology on computerized information systems

The characteristics of computerized information systems in small batch production were related to the requirements for flexibility and frequent changes. The computerized information systems therefore consisted of input- and core-systems, and the systems were integrated and decentralized. Further, there were only fixed reports but reports from input-systems contained forecasted as well as actual information. The operations used in processing information (in addition to updating and aggregating) were transposing in input-systems and inferring in core-systems. Finally, only a small number of frequencies, collecting as well as reporting, were used and they formed a limited range.

In large batch production the characteristics of computerized information systems were related to

the requirements for efficiency. The computerized information systems hence consisted of core- and output-systems; systems were integrated, and centralized as well as decentralized computerized information systems existed. Further core-systems produced only fixed reports which contained forecasted as well as actual information. The operations used in processing information (in addition to updating and aggregating) included inferring in core-systems and transposing in output-systems, and these operations were used more extensively than in small batch production and process production. Finally, a large number of frequencies, for both collecting and reporting, were used. Continuous frequencies were used as well as a broad range of other frequencies.

In process production, efficiency depends on the inflow of materials. The computerized information systems therefore consisted of input- and core-systems and computerized information systems were not integrated. They were however decentralized. Further, there were only fixed reports, and reports from input- and core-systems contained forecasted as well as actual data. The use of transposing and inferring operations (in addition to updating and aggregating) were limited. Finally, only a small number of frequencies, for both collecting and reporting, were used and they will form a limited range. The frequencies had longer periods than in small batch and large batch production.

In summary, the computerized information systems were more elaborated when efficiency was required than when flexibility was required. In the former case, there were larger territories, and the computerized information systems encompassed more application areas. The reports produced were variable and packaged as well as fixed. A larger number of frequencies, which form a broad range were used.

9.3.2 Impact of environment on computerized information systems

The impact of the environment on computerized information systems is supplementary to that of technology, and therefore only modifies the impact of technology.

The characteristics of computerized information systems in a stagnating environment were related to the requirements for companies to react and adjust with a short time perspective. The computerized information systems therefore encompassed broader range of output-systems, and they were integrated and centralized. Further, there were variable, packaged as well as fixed reports. The operations used included both transposing and inferring. Finally, several frequencies were used, forming a broad range.

In an increasing environment the characteristics of computerized information systems were related to the potential for the organization to adapt with a long-term orientation. The computerized information systems thus encompassed a limited number of output-system, and they were non-integrated and decentralized. Further, only fixed reports were produced. The operations included inferring but not transposing. Finally, only a limited number of frequencies were used.

In summary, the impact of a stagnating environment on computerized information systems resembled the impact of large batch production; similarly, the impact of an increasing environment on computerized information systems were in a similar direction to the impact of small batch or process production. Hence, it is hypothesized that the impact of large batch production on computerized information systems will be reinforced in a stagnating environment. Further it is hypothesized that the impact of large batch production on computerized information systems will be modified in an increasing environment. Similar tendencies will be found in small batch production.

9.4 Contingency studies of computerized information systems and computer system design

In previous chapters a number of contingency studies of computer system design (section 2.5) and of information systems and computerized information systems (section 4.2) have been reviewed.

In the study reported here, attention was given to computerized information systems. Two contextual factors, technology and environment, were considered. These were derived from and used in accordance with contingency studies of organizational structure. This procedure seemed reasonable on the grounds that a computerized information system is a subset of the structure of an organization (cf chapter 1).

A number of contingency studies (reviewed in section 2.5) have computer system design as their focus. These studies were found to vary with regard to both the contingency variables and dependent variables they considered. Moreover contextual variables observed were not found to be directly related to the contextual variables of organizations. In general, the amount of empirical support was poor and most studies were speculative. Alloway (1976) found empirical support for the influence of design-task and organizational context. Some studies were directed towards evaluating system design methods (Ciborra et al 1980, Taggart & Tharp 1975, Tharp & Taggart 1976).

Hence, previous contingency studies of computer system design differ in several points from the study reported here. Perhaps the most important differences concern the object of study and the contextual factors.

Another group of contingency analyses have information systems or computerized information systems as the object of study (reviewed in section 4.2). These studies were found to have extensive theoretical support, as they were firmly grounded in existing research on the influence of contingency variables in organizational structure. However, empirical support for the work was largely lacking, except for a study of the influence of work-unit technology on information systems (Daft & MacIntosh 1978, McIntosh 1981, MacIntosh & Daft 1978). Theoretically as well as empirically there was considerable agreement between the analyses on the contextual variables identified, these being the environment or the technology of an organization. Most frameworks related the contextual variables to information systems in general — rather than to particular production systems which constitute the focus of the study reported here. The contextual variables identified in both cases are environment and technology. The hypotheses proposed in this study, though more detailed, are in line with those proposed in the contingency framework of information systems.

9.5 Implications for computer system design

In this study a contingency framework for computerized information systems has been proposed. It is further suggested that computer system design is contingent on organizational context and structure. A contingency framework, specifically developed for computer system design, is therefore proposed (Figure 9.4).

In general terms, computer system design comprises three phases. The first phase involves determining the objectives for a computerized information system and is followed by analysis, and then construction.

It is argued that organizational context will have important implications for computer system design. In this study, empirical support was found for the proposition that computerized information systems are contingent on contextual factors. It follows that computer system design is similarly contingent on contextual factors.

Similarly, it is argued that organizational structure will have important consequences for computer system design. In this study it was argued that computerized information systems are a subset of the structure of an organization, and that other features of organizational structure will thus have implications for the computerized information systems. Analogously, computer system design is similarly contingent on organizational structure.

The significant point is that organizational context and structure will not only have an impact on

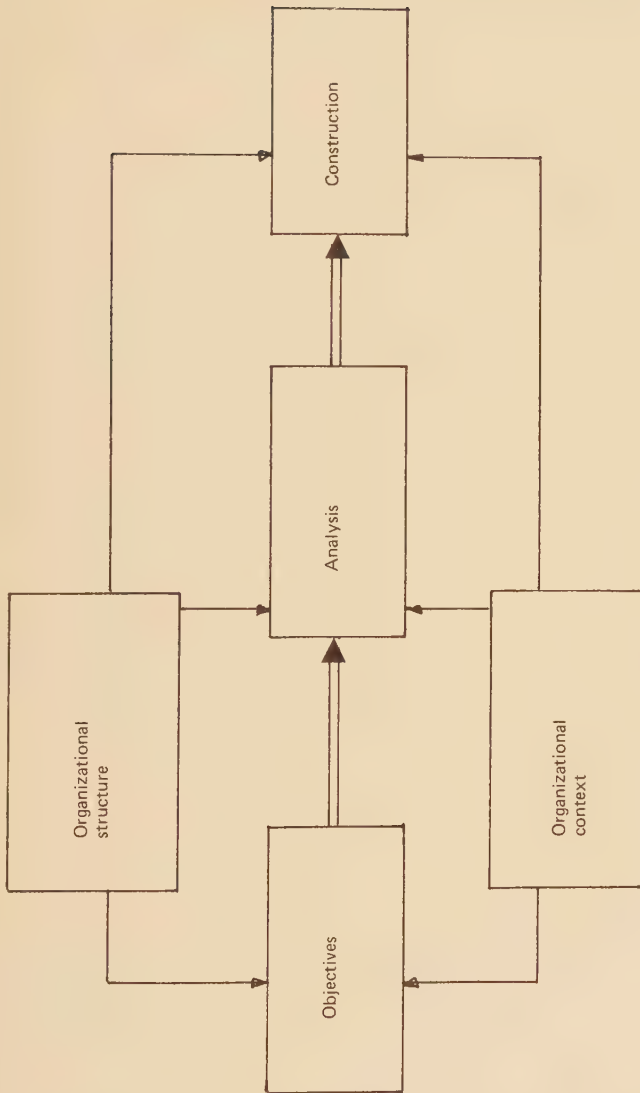


Figure 9.4 A contingency framework for computer system design.

determining objectives but also on analysing and constructing computer systems. The implications are thus manifest both on the strategic level and on the level of computer systems design itself. As regards objectives organizational structure and context affect both the choice of computerized information system at the strategic level and the characteristics of a computerized information system on the level of design itself. Their implications for analysis and construction include the development and implementation of new methods and new techniques on the strategic level, and the choice of design methods and techniques.

Tailoring a computerized information system to organizational and user needs is a challenging task. A contingency framework indicates that the task may be aided by taking a number of guidelines into account.

The designer should *focus on the context and structure of the organization in addition to its goals*. The relationships between computerized information systems and an organization are more complex than is frequently realized. An analysis of goals generally results in unclear and indeterminate specifications and supplementary restrictions are based on ideas about a universal organization and not on a specific understanding of the organization in question. Computerized information systems which are tailored to goals will not necessarily be useful to the organization: they may provide too much or too little information, or they may provide inadequate and irrelevant information, etc. An analysis of the context and structure of an organization improves the understanding of the organization in question. When the computerized information system is congruent with the context and structure it will serve the organization well. Context and structure are enduring factors, representing the constraints and tasks an organization must deal with, so they are fundamental for organizational goals and objectives.

Second, *organizations often use several production technologies and work in separate environments, so a centralized computerized information system will not suit every organization*. The assumption that all divisions are similar, or the temptation to ignore differences in order to simplify the design and administration of computerized information systems is a crucial mistake. Companies should have different computerized information systems serving the requirements of different divisions.

Finally, *a contingency approach to computer system design represents a supplement to existing models and methodologies*. It is not an alternative to the life cycle mode, participative design or prototype design.

10. POSTSCRIPT

In the research work reported in previous chapters, attempting to develop a contextual framework for computerized information systems, a contingency approach was adopted. The research study was formulated based on the theoretical framework of contingency theory around the middle of the 1970s. Recent developments in contingency theory have modified and extended this framework in important respects; in particular the criticisms towards contingency theory have increased, and several additional limitations have been identified in recent years, which have jointly resulted in suggestions for improvement and revisions. Some suggestions even go beyond contingency theory.

In this postscript the important issue, whether the research results obtained are obsolete, is discussed. It is argued that they are not obsolete but valid only with respect to a particular organizational strategy.

Contingency theory has been reviewed previously (chapter 3), it is therefore only briefly summarized in this postscript in order to emphasize some major points concerning its contribution to organizational research and theory. Next, criticisms of contingency theory are reviewed. Finally, the implications of the critique are discussed with reference to the research reported and the conclusions obtained on the impact of environment and technology on computerized information systems.

10.1 The contribution of contingency theory

Classical management theory can be characterized as prescriptive, non-empirical and universalistic in orientation. It maintains that certain factors universally determine the performance of any organization, irrespective of the circumstances. Accordingly it aims to establish principles for good organizational design, common to all organizations. In contrast the orientation of contingency theory is empirical, descriptive and non-universalistic.

Having introduced the notion of contingency theory, a caveat is required. Contingency theory is not a theory at all in the sense that a theory is a well-developed set of interrelated propositions. Rather, it is an orienting strategy, suggesting approaches for studying organizations, ways in which a phenomenon ought to be conceptualized or methods for explaining the phenomenon.

Contingency theory is predominantly empirically and descriptively oriented. In general research has addressed the following questions: First, *how and why do industrial organizations vary in structure*, and secondly *why do some structures appear to be associated with greater success for*

the organization than others. Systematic comparative studies of the relationships between organizational structure and contextual variables have been the guiding principle. Researchers have attempted to discover the extent and degree of empirical variation in organizational structures and to establish the conditions of such variation. Further research, deepening our understanding of the processes which influence the structure and function of organizations, has been stimulated by the partialness of the results obtained.

Contingency theory does not support a universal design of organizations, according to which there is one best way to organize, instead it adopts a relativistic stand. There is one basic tenet: There is no one best way to organize, or in other words one particular way of organizing is not equally effective under all conditions (Galbraith 1973).

The results of empirical research in contingency theory are interpreted within a managerially oriented framework, which asserts first that it is in the interests of all parties that organizations should work efficiently, and second that the effective operation of an enterprise is dependent upon there being an appropriate match between its structural arrangements and the nature or the demands placed upon it by its context. Accordingly, it is assumed that performance is improved when organizations are designed to fit their contexts. Hence, the causal pattern implies a model where performance is seen as a dependent variable and structure as an intervening variable. The independent variables, which are constituted by contextual factors, are assumed to impose certain, primarily economic, constraints on structural variables, thereby determining the structural variables, but not completely.

Three directions of research have been particularly influential within contingency theory. Each recognizes and postulates the effect of a major contextual factor. One direction is particularly concerned with the influence from the environment, a second with technology or the physical nature of the transformation process, and a third with size.

The concern with *environment* starts from the observation that organizations are to some degree dependent upon exchange with outside parties, for import and export. This dependency is considered to impose a degree of constraint upon the decision-makers in an organization. For example, it has been found that the more variable and complex the environment, the more open and adaptive the structure, the lesser the degree of specialization and the greater the need for intra-organizational coordination and integration (Burns & Stalker 1966, Lawrence & Lorsch 1967, Emery & Trist 1965).

Researchers have found strong relationships between *technology*, or the physical nature of the transformation process, and a variety of structural outcomes (Perrow 1970, Thompson 1967), Woodward 1965). Others, on the other hand, argue that technology is largely an insignificant variable (Pugh & Hickson 1976). The most developed approaches involve studies of operations technology in manufacturing organizations (Woodward 1965) and the more generalizable analysis of materials technology (Perrow 1970). Perrow (1970) suggested that the more predictable and stable the raw materials (physical or informational materials) used, the more specialized and more formalized the structure (fewer exceptions need to be handled and search is analyzable).

Size has long been considered an important factor in organizational research, for example size and bureaucracy have been found to be related (Pugh & Hickson 1976). The effects of size on organizational structure can largely be seen to involve two arguments. The first argues that size, particularly growth in size, poses problems of control and communication (Williamson 1970, Weick 1969). A second argues that increasing size offers more opportunities to reap the benefits of increased specialization (Child 1977), as well as increasing financial resources.

To conclude, the important contribution of contingency theory has been in repudiating the idea of universal organizations, i.e. that the same structure applies to all tasks.

10.2 Criticisms of contingency theory

Turning now from a summary of the contribution of contingency to a critical examination of contingency theory, it is important to distinguish criticisms of two kinds. First, there are criticisms taking a *methodological* view, these criticisms basically accept the usefulness and appropriateness of a contingency framework. Secondly, other criticisms involve an analysis of the fundamental, explicit as well as hidden, *assumptions* in contingency theory. The assumptions in contingency theory may, further, be divided into two groups: those concerned with *performance* and those concerned with *choice and constraint*.

10.2.1 Methodological criticisms

The methodological criticisms comprise definitions of variables, relationships between variables, and methods of analysis.

The importance of particular contextual factors has been discussed. Thompson (1967) and Woodward (1965), whose attentions were directed towards core-activities, argued that technology was most important in determining organizational structure. Pugh and Hickson (1976), whose attention were directed towards non-core-activities, found size to be more important. In a reexamination of their results, however, technology emerged as a variable of major importance (Aldrich 1972).

Conceptual definitions are often too global, they will have to be modified to include several aspects of structure and contextual factors, rather than a single ideal description. Statements like "uncertain environments require organic structures" are oversimplified (Pfeffer 1978), instead more detailed propositions need to be developed relating particular aspects of structure to particular aspects of environment.

There is considerable confusion in the literature as to the conceptual and operational definitions of technology as well as to the relationships between technology and structure. Stanfield (1976) argues that classification theories need to take account of overlaps between technology and structure.

Organizational size is an extensive and difficult field, which involves problems with defining and delimiting an organization. Kimberly (1976) critically reviewed the role of size as a variable in studies of organizational structure. Conceptual definitions of organizational size were found to be lacking, although two competing conceptual definitions of size were identified: first size is a structural characteristic of an organization, second size is one of several dimensions of the context of an organization. Kimberly (1976) argued that a more differentiated approach is necessary, one which directs attention to particular aspects of size, to their degree of importance for specific organizational characteristics, and to the conditions for relationships between these aspects and organizational characteristics. Four aspects of size were suggested: the physical capacity of an organization, the personnel available to an organization, organizational inputs or outputs, and discretionary resources available to an organization. The personnel aspect is particularly relevant with regard to social control. The physical capacity and input aspects of size are assumed to be most relevant with regard to the problem of the structure of work.

Other criticisms have considered the relationships assumed. Relationships are often treated as linear. However, relationships between variables may differ in different contexts. Also relationships may be curvilinear or non-monotonic (Miller 1981, Schoonhoven 1981).

Criticisms have also referred to the use of bivariate analysis when multivariate analysis would be more appropriate and accurate (Schoonhoven 1981). Factors which are not considered may be influencing or may account for an observed relationship. This leads to arguments for organizational "gestalts" (Miller 1981). "Gestalts" involve the identification of richly described natural clusters among a broad variety of environmental, organizational and strategic variables.

10.2.2 Performance

Though the methodological criticisms involve several important aspects, there is agreement among these critics on the usefulness of contingency theory. Other criticisms however question the usefulness of contingency theory. This critique will be reviewed, in this section on performance, and in the next on choice and constraint.

Contingency theory asserts that organizations must acquire resources and achieve levels of performance which are sufficient to enable the organization to survive and to work effectively. Furthermore the efficiency of any structural arrangement can be evaluated in terms of the improvement — or the deterioration — in organizational performance it brings about for a particular contextual configuration. However, there are a number of problems with the concept of performance: the conceptualization of organizational performance, the role of performance, the influence of non-organizational variables on performance.

It was previously noted that in contingency theory performance is seen as a dependent variable, organizations are designed to match their contexts in order to optimize performance. However, organizations pursue a variety of goals. Furthermore organizational performance, even in respect of one goal, is multifaceted. Improving organizational performance can refer to any of a number of facets: effectiveness, productivity, internal integration, adaptability and flexibility (Dawson 1979).

The second problem concerning performance refers to the *role of performance* in organizational design. For example, studies have revealed a relationship between poor performance (in profit and growth terms) and tight budget and cost controls (Child 1977), between poor performance and a failure to develop adequate integration mechanisms (Child 1977). The implications of these findings are ambiguous; hence in such cases it needs to be investigated whether the tight controls or inadequate integrative mechanisms lead to poor performance, or whether poor performance leads management to institute tighter controls and not to adopt integrative mechanisms (e.g. coordinators, frequent meetings) which are inherently expensive.

The role of performance is dual: it is an outcome as well as an input. In addition to the possible effects organizational structure has on performance, managers receive a vital feedback of information in the form of performance standards, achieved performances and forecasted performances which may stimulate them to make adjustments to structure (Child 1972, 1977) attempting to correct for poor performance, or sustaining and accommodating good performance.

A primary condition would seem to be that the operation of any particular structural arrangement depends upon a sufficient supply of resources. If the level of performance exceeds some satisficing level, and assuming that this level represents a degree of return that is at least sufficient to secure resources required for fulfilling present and future plans, then the decision-makers may adopt structural arrangements which accord better with their preferences despite some extra administrative costs to the organization. Performance standards may themselves allow for some slack. Conversely a declining level of performance implies decreasing resources, and may therefore lead to decisions aimed at effecting administrative economies.

The last problem concerning performance refers to the *influence of non-organizational variables*. There is a lack of conclusive evidence to demonstrate that matching organizational structure to prevailing contingencies means important improvements in organizational performance. In addition Child (1977) has cited research-studies into business organizations which suggest that other strategic considerations may have considerable influence on performance, apart from the structural design adopted. There is ample evidence that normal rates of profit and growth vary among industries and markets. Furthermore technologies vary in respect of economies of scale and possibilities for standardization and long production runs, and these variations may have important implications for the performance of firms (Child 1972, 1977). Poor choices of markets and technologies may cause performance to suffer, as may the failure to seize opportunities for profitable investments in production facilities or research and development, and vice versa luck may

improve performance.

A vast number of variables may influence the level of organizational performance achieved. Some of the variables are structural or internal to the organization, others are non-organizational or external to the organization; they may further vary in importance.

10.2.3 Choice and constraint

Other important criticisms dealing with contextual and structural factors and their relations question the usefulness and accuracy of contingency theory, as it does not account for discrepancies between the actual structure and the structure predicted from contextual contingencies. In particular three major shortcomings are identified: the disregard of the interactions between individuals in generating the structure of an organization, the presence of multiple contingencies and requirements for consistency, and finally the possibilities for organizations to exercise choice concerning contextual and structural factors.

It has previously been mentioned that research adopting a contingency approach has on the whole addressed two questions: conditions for structural variations, and the success of different structures. Researchers have therefore sought to study the appropriateness of different structural arrangements, in so doing they have concentrated interest on the fixed and stable aspects of organizations, i.e. on structure as it exists at any point of time. These aspects are, however, merely temporary manifestations of a more fundamental and ongoing process, which involves the interactions between individuals from which the structure is created (Bowey 1976, Burrell & Morgan 1979). The goals and objectives sought by individuals and groups may not be shared, and power resources, such as information, expertise, rewards and sanctions, may be differently accessible. Hence, conflicts of interest and distribution of power are potentially important features of organizations. The political process encompassing the ways in which conflicts are expressed and resolved can have a profound influence on organizational structure (Pfeffer 1978).

Some contingency studies have investigated the impact of environment on organizational structure, others have investigated the impact of technology etc. Hence, attention has often been limited to a single contingency, although *multiple contingencies* will be present at the same time (Child 1977): An organization needs to consider simultaneously contingencies posed by the environment in which it operates, by the technology it utilizes, and by its size etc. Further an organization may operate in several environments and utilize several technologies etc.

In a configuration of different contingencies each may have distinctive implications for organizational design. The structural implications of each contingency are unlikely to be the same. Consider, for example, a firm operating in a dynamic environment and utilizing a mass-production-type of technology. According to the guidelines offered by contingency theory, should the organization set a limit on the degree of internal formalization in order to remain flexible and adaptable, or should the organization allow this to rise in order to be able to operate its mass-production system efficiently?

Contingencies may not only be conflicting, they may also vary in importance, for example Child (1977) argues that size is more important in a stable environment than in a variable one. Furthermore the impact of conflicting contingencies may be neutralized.

In addition multiple contingencies draw attention to requirements for *structural consistency* (Child 1977), this refers to the degree of conflict between aspects of structure in an organization. When there is a low degree of conflict, organizational structure can be seen to be more consistent, and structural aspects support each other. Some preliminary findings indicate that the consistency of structural design is significantly associated with levels of organizational performance (Child 1977). Multiple contingencies and structural consistency imply further that contextual and structural factors cannot be considered in isolation, instead they form clusters. Hence an

approach which considers organizational "gestalts", i.e. clusters among a broad variety of strategic, contextual and structural factors, has been suggested (Miller 1981). It is argued that the predictive power of organizational "gestalts" is superior to that of single contextual factors.

A final shortcoming of contingency theory refers to the practice of treating contingencies as given and constraints as constant. This ignores that some organizations may be less dependent on their environments or contexts than other organizations are. It further ignores that organizations may have some opportunities for selecting or manipulating their contexts (Child 1972, Pfeffer 1978). This is clear with regard to environments, but similar arguments can as well be applied to the choice of technologies and other contextual factors.

The argument that organizations may choose their environments (Child 1972) can briefly be outlined as follows. The starting-point is the observation that any organization needs to establish an "organizational domain" (Levine & White 1961) including decisions on products (sometimes even specifying fields of application), customers, and means required to provide the products. This has important implications: different sectors of the environment can be distinguished in terms of their importance for the goals and functions ascribed to an organization. Thus several boundaries proceeding outwards from the organization, i.e. the *outer* boundary of the environment, are distinguished (Thompson 1967). Similarly the distinction between environment and the organization itself, i.e. the *inner* boundary of the environment, is relative to the goals and actions of the organizational decision-makers (Starbuck 1976). Hence the inner and outer boundaries of the environment of an organization are variable and subject to choice.

Not only do organizations select their environments, if they command sufficient power, they may attempt to influence and modify the conditions prevailing with respect to contextual factors (Child 1972), thereby avoiding changes in structural arrangements. Major structural modifications or changes are often costly to the organization as they bring with them conflicts and uncertainty, as individuals and groups fight to maintain their power, their positions and their responsibilities (Pfeffer 1978).

Organizations attempt to modify and change their environments in respect of both their competitive interdependencies and their symbiotic interdependencies. Organizations endeavour to manage their symbiotic interdependencies (i.e. relations with suppliers and customers) in order to assure themselves of reliable supplies of resources and reliable demands for products; for example advertising is often effective in influencing customers. In order to reduce and limit competition organizations endeavour to manage their competitive interdependencies. To these ends organizations have long used strategies such as contracting, cooptation, coalescing and diversification (Galbraith 1977, Pfeffer 1978, Thompson 1967).

A final choice refers to the selection and modification of structural arrangements (Miller 1981). According to the "principle of equifinality" (Katz & Kahn 1966) it is logically reasonable to expect to find many ways of succeeding in the same context. In cases where such opportunities exist, for example when an organization is less dependent on its context, an organization may choose a structure which accords with its preferences, for example with regard to organizational centralization, and whose administrative costs are acceptable. Confronted with for example an environmental change, an organization may have opportunities to choose among a number of structural strategies to select the one most suitable or preferable, involving the smallest amount of reorientation.

The argument referring to choice of environment can be extended to other contextual factors, thus contextual factors may be selected or they may in some instances be modified to fit the existing structural arrangements. Choice also includes selecting and modifying the structure. Contextual factors cannot be regarded as direct sources of variation in organizational structure, they may themselves be subject to planned change. The conclusions imply that contextual factors are not major constraints for an organization. Moreover, an organization which is completely tuned to a particular context may be unable to survive if the context undergoes considerable changes.

Three shortcomings have been reviewed: the disregard of the interactions between individuals in generating the structure of an organization, the presence of multiple contingencies and requirements for consistency, and finally the possibilities for organizations to exercise choice as regards contextual and structural factors. The last shortcoming is clearly the major one; and it is to some extent implied by the other two, disregarding interactions between individuals implies ignoring the process of choice, multiple contingencies emphasize the need for choice.

In order to take account of the shortcomings, particularly the last one, contingency theory needs to be amended. A more comprehensive framework is required. Child (1972) therefore introduced the concept of *strategic choice* which directs attention towards the notions of corporate strategy and dominant coalition.

Attention is directed towards the strategy of an organization. Chandler (1962) has found support for the hypothesis that strategy ultimately determines structure, for example a strategy of product-market diversification leads to a divisionalized structure. *Strategy* can be defined as the determination of the basic long-term goals and objectives of an organization, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals. Modifications of organizational goals were found to be major sources of changes in size, technology and location. Further, it was found that a new strategy required a new or at least a refashioned structure, if the enterprise was to be operated efficiently.

Child (1972) further argues that strategic choice directs attention towards the dominant coalition (Cyert & March 1963, Thompson 1967), and thereby to the distribution of power and to changes in this distribution. The *dominant coalition* will consist of decision-makers who have access to critical resources for controlling and reducing uncertainty (Thompson 1967). To the extent members of the dominant coalition control critical resources they will possess the power to decide upon an organization's structural rationale. It is not implied that members of the dominant coalition in an organization are formally designated, nor that they remain constant, rather it is expected that the composition of the dominant coalition will shift through time. In addition it is not implied that the influence and power of other members of an organization is non-existent, only that it is limited as those members do not have access to relevant critical resources.

Child (1972) concludes that strategic choice is the critical variable in a theory of organizations. Contextual factors, which contingency theory regards as independent determinant of organizational structure, are within the perspective of strategic choice linked together as multiple points of reference. Strategic choice is thus closely related to an identification of "gestalts" of strategic, contextual and structural factors (Miller 1981). Further strategic choice recognizes strategic decision-making as the operation of an essentially political process.

10.2.4 Conclusions

It is clear from the previous review that the criticisms of contingency theory are numerous and varied. The methodological criticisms imply an exhortation to carefully define concepts and relationships. Furthermore the use of models incorporating several contextual and structural variables is continually being facilitated as new and more complex methods of analysis are becoming available.

The criticisms in respect of performance emphasize that the role of performance needs to be carefully considered in contingency approaches. The problems of conceptually and operationally measuring performance remains considerable, in addition there is a need of comparability and representativity across organizations and industries.

Finally, the most important criticisms are those concerned with choice and constraint. Do these criticisms require us to reject completely the idea that there are environmental, technological and other contextual factors which influence organization structure? This is hardly the case: First, the time-scale involved is important. Secondly, although strategic choice introduces more volun-

taristic models, it is rarely completely free.

The influence of contextual factors is to some extent dependent on the time-scale involved. The present environment and technology refer to a particular strategy, they are therefore the result of strategic choice. Decisions regarding the choice of environment and technology are unlikely to be revised frequently, a change in the present environment and technology will probably come about through a change of strategy. In the short term therefore, the contextual factors may pose constraints, though in the long term these too may be subject to choice.

Moreover, it is hardly the case that a strategic choice is always completely free or unconstrained. Rather, a strategic choice is only possible within certain boundaries posed by, for example, economic conditions. Strategic choice implies a collection of interrelated choices — whether previous, concurrent or even future — where each choice constrains, and is constrained by, other choices in the collection. Hence the range of choice is constrained, although some choices, for example those late in a sequence, may add little in terms of constraints.

So an emerging framework will need to incorporate and integrate relevant ideas of choice as well as constraint. An organization may have possibilities for certain choices, but it may concurrently be subject to constraints, such as general economic conditions, needs for investments or available resources. The balance of choice and constraint will probably shift during the life-time of an organization, from a dominance of choice to a dominance of constraints. Such a shift will come about due to inertia, which means that contextual factors will increasingly be perceived as constraints. An organization develops inertia as it continues operating in a particular context and is constrained by past choices — and past successes.

10.3 A contextual framework for computerized information systems and criticisms of contingency theory.

The research reported in the previous chapters was based on the idea that different organizations require different computerized information systems with different characteristics. In the framework proposed (chapter 6) computerized information systems are considered contingent upon two contextual factors, technology and environment. Detailed concepts have been proposed for describing environment and technology (chapter 3) and computerized information systems (chapter 5). The empirical results obtained, formulated as a number of detailed hypotheses (chapter 8 and 9) provide illustrations of the proposed model for describing computerized information systems (Figure 5.4). The detailed hypotheses are consistent with the original, general hypothesis, which states that differences in the characteristics of computerized information systems, can to some extent, be explained by differences in organizational contexts.

An important issue is the relevance of the criticisms of contingency theory, which have been reviewed in the previous section, in respect of the research work reported. In this section the object is to assess the relevance and applicability of the criticisms with reference to the framework proposed and the results obtained. The discussion will be limited to methodological criticisms and to criticisms referring to choice and constraint.

10.3.1 Implications of methodological criticisms

One of the methodological criticisms concerned the common lack of conceptual definitions in contingency studies. It has been an important part of the research reported previously to develop concepts for describing computerized information systems based on an examination of existing models for describing computerized information systems. The workability of the proposed model for computerized information systems has been demonstrated; although the usefulness of the model still remains to be demonstrated, since this will require using the model as a tool for computer system design.

Another methodological criticism referred to the propensity in contingency studies for treating relationships between contextual and structural variables as linear. Relationships may, however, often be curvilinear or non-monotonic (Miller 1981, Schoonhoven 1981), in such cases the notion of linear relationships implies that the relevance of relationships found and results obtained is restricted. In the study reported no explicit relationships have been assumed, although in presenting the empirical data (chapter 8), particularly in the figures presenting data on computerized information systems in the companies studied (Figures 8.1 – 8.8), the relationships are basically linear. The procedure may be questioned regarding the relationships and their applicability in general. Thus, the implication is that the results obtained and the relationships assumed, regarding the impact on computerized information systems, are applicable mainly to the nine companies studied, and they give only some indications of results to be expected in other companies.

10.3.2 Implications in respect of choice and constraint

The criticisms are first discussed with reference to computerized information systems, finally their implications for the research work reported are assessed.

One shortcoming of contingency theory is the disregard of interactions between individuals in generating the structure of an organization (Bowey 1976, Burrell & Morgan 1979) and in consequence of changes in the distribution of power (Pfeffer 1978). Computerized information systems are important power-bases, and they may be used to strengthen the influence of some groups or individuals in an organization. The introduction of computers in an organization may therefore result in a changed distribution of power, for example with the EDP-department as the winner (Stymne 1966). Nevertheless, only scant interest has been devoted to issues of conflict and to political aspects of computers, computer system design and computerized information systems. However, Pettigrew (1973) studied the decision to purchase a new computer using a perspective of power and politics. He found that the final decision was influenced by the power-bases, which were available to and used by the parties involved in order to influence the supply and flow of information. Similarly, Borum and Enderud (1981) studied some cases of computer system design using a conflict-oriented perspective. They argue that computer system design has a potential for giving rise to conflicts, by for example removing some filters controlling conflict. Organizations may yet have access to mechanisms for controlling, reducing or redefining conflicts during computer system design (for example selecting participants, changing project-time-plans). Moreover, Mumford and Pettigrew (1975) argue that internal political processes are major sources of uncertainty and that political behaviour is likely to be a particular feature of large-scale innovative decisions, such as those associated with the introduction of computers and the implementation of computerized information systems.

A second shortcoming referred to the fact that organizations operate under the presence of multiple contingencies, and they further require consistent structural arrangements (Child 1977). It can be argued that computerized information systems may play a dual role in this case. Multiple contingencies imply increasing requirements for processing information, and computerized information systems are a means an organization may use to increase its capacity to process information. Hence, it could be that computerized information systems may make it easier for an organization to accommodate multiple contingencies. On the other hand, computerized information systems need ideally to be designed in order to match multiple contingencies, and ideally they must be consistent with other information systems as well as other structural features in an organization.

It is a third short-coming that contingency studies generally treat constraints as given. Instead, organizations may have opportunities for selecting or manipulating their contexts as well as their structural arrangements (Child 1972, Pfeffer 1978). Organizations may similarly have opportunities for choice in respect of computerized information systems. Computerized information systems are only one alternative, other alternatives involve structural changes or a change of context. Certain forms of equifinality (Katz & Kahn 1966) may be possible, in terms of other

means for processing information apart from computers.

Competitive pressures are often important inducements when organizations introduce computers or computerized information systems (Bjørn-Andersen & Hedberg 1977). The organization then decides to remain in the previously chosen context, in order to remain competitively efficient it therefore needs to introduce computers when the competitors do so. Alternatively the organization may decide to remove itself to another context, where conditions may be perceived as favourable or suitable.

Based on data from an international study of Computerized Information Systems and Management (CISM), Robey (1981) tentatively concludes that computerized information systems do not appear to limit structural choices, at least in the eight organizations studied in five countries. The research results indicate that computerized information systems may show considerable flexibility in adapting to a variety of organizational forms, without necessarily changing them. Computerized information systems were found to be associated with greater centralization in some organizations. In contrast computerized information systems supporting lateral relations were found in other organizations. (The characteristics of the computerized information systems are not clear, it is therefore not clear what the differences are between computerized information systems supporting centralization and those supporting lateral relations).

Finally, computerized information systems usually represent considerable investments, in machinery, programs, databases as well as specialists. Changes in computerized information systems can therefore be expected to be expensive and difficult to implement, and hence they are likely to be avoided. Instead a contextual change may be accommodated by changing other structural arrangements apart from the computerized information systems. Of course, changes in context may require organizational changes which are not so limited.

In the study reported only two contextual factors have been included, environment and technology, yet only the impact of production technology was considered while that of information technology was ignored. Further, in spite of computerized information systems having been defined as subsets of the structure of an organization, other structural factors were ignored as were their relationships with computerized information systems. With regard to future research an expanded framework is needed for the study of computerized information systems. Such a framework needs to include several contingencies, as well as relationships between computerized information systems and other structural arrangements. In order to include interactions between individuals and groups the framework could be further expanded or an alternative framework used.

In the long run the context of an organization is likely to undergo changes, while it may remain constant in the short run. Computerized information systems generally have short expected lifetimes and it is therefore unlikely that an organization selects its environment and production technology on the basis of its information technology and computerized information systems. It seems more likely that information technology is chosen and computerized information systems are designed in order to match the existing environment of an organization. Hence, the framework used and the research results obtained are relevant within the scope of a strategy, which is chosen and not given by nature. The choice of a strategy limits the alternatives possible with regard to environment and technology, which may be intervening variables, and thus environment and technology may further limit the alternatives with regard to computerized information systems.

10.4 Conclusion

A number of criticisms have been reviewed. They imply that the research results have restricted relevance, this means for example that an expanded framework is needed to allow for multiple contingencies, or issues of power and politics.

Though case studies have been used in the research project, the arguments put forward are basically statements about correlations between organizational context, i.e. environment and technology, and computerized information systems. The criticisms of contingency theory are not so much against correlations, but far more against interpretations in terms of cause- and effect-relationships. It can therefore be argued that, given some limitations, the research work reported can yet be seen to be applicable to relations between context and computerized information systems. There are two arguments which support this assertion: Information systems for a production system in an organization cannot be derived exclusively — nor directly — from logical steps in the production process, instead they will vary with the chosen environment and technology. Second, although strategic choice is of primary importance, environment and technology may be intervening variables in the company strategy. It can thus be concluded, that present (and maybe planned) environment and technology give a good indication of the chosen computerized information systems and their expected characteristics, because environment and technology cannot be changed as fast as computerized information systems.

APPENDIX

Only brief descriptions of the nine companies studied have been presented previously (chapter 7). The more detailed descriptions are to be found in the appendix.

Each company is presented following a common outline. Each case-description begins with some general data on the company, it then continues with data on technology and environment, finally it gives short descriptions of the computerized information systems and the generic characteristics of these.

The real identity of each company has not been revealed although each has been given a pseudonym. The companies will be described in alphabetical order.

A1. BIG MILL DIVISION

1. General Data

Big Mill produces and sells a foodstuff in a number of qualities and package-sizes. There are two producers and sellers of the product in Denmark, Big Mill has roughly 85% of the domestic market. Both companies also export the product, primarily to members of the European Community or to Scandinavian countries.

Big Mill was founded a century ago. Today the company has one major product, a foodstuff, but it also manufactures supplementary products, e.g. engineering products used in extracting raw materials for the major product and in producing the foodstuff.

The major product accounts for roughly 80% of company sales. In 1976 the sales of the major product amounted to 950 mill D Cr (roughly 750 mill Sw Cr). The number of employees in Big Mill was around 1800.

The product is mature one, a basic foodstuff. Consumption on the domestic market varies very slightly. Excess production is exported. The prices on the domestic market are stable, but the prices on the export market vary. Export is in current prices.

The market and the two companies are regulated. The regulations are determined by the EEC-commission. There were regulations even before Denmark became a member of the European Community in 1973, however they were modified by Denmark's entry into the community.

Big Mill has used computers since the middle of the 1960s. The company group uses computers not only in connection with the major product manufacture by Big Mill but also for other products made by other divisions in the group.

The computerized information systems used in connection with the major product are purchasing, manufacturing, stock-holding, invoicing and sales-statistics. The computerized information systems are all batch systems, and are used only for the foodstuff. The computerized purchasing and manufacturing systems are the biggest computer systems in the company group as whole, and they are constantly being developed and modified. The computerized invoicing and sales statistics systems are less complex than similar computer systems used in connection with other products in the company group.

2. Technology

Product	A limited line of products, which vary only in respect of size.
Work flow	The work flow can be subdivided into two: process production followed by large batch production. The work flow in process production consists of a fixed sequence of five steps, and in large batch production involves only a few steps.
Material flow	Production is a combination of process production and large batch production; in between the product is put into storage. Production in large batches is made for stock and is based on a production and sales plan.
Techniques	Production is heavily mechanized and automated, particularly in process production.

3. Environment

Customers	There are a limited number of domestic customers (considerably less than Consolidated Mill has), as each customer is required to buy a certain minimum quantity according to EEC-rules.
Competitors	On the domestic market there is one smaller competitor. The market is however divided between the two companies, neither encroaching on the other ones market. In the export markets competition varies. Big Mill exports only to a few markets, both inside and out-

side the European Community. The regulations of the EC-commission apply to community markets. There are few competitors in the non-community markets.

Suppliers	The raw material is bought from a large number of regular suppliers (fewer and bigger than in the case of Consolidated Mill) on the basis of long-term contracts. The supply of raw material has been stable, with only minor changes.
Regulations	There are regulations which affect both the supply of raw material and the prices of the foodstuff. At Denmark's entry into the EEC, the regulations were adapted to those applying in the community. They have a duration of 10 years. The regulations have kept the Danish production of the foodstuff on a comparatively stable level, which is in excess of domestic consumption. The regulations affecting total production is not as strict as in the case of Consolidated Mill. Charges are levelled on excess production.

4. Computerized information Systems

Purchasing	Recording preliminary quantities of raw material from each supplier. Each supplier is allowed a certain quota depending on previous quotas and fulfillment of these. Contracts are made in quantities of the finished product.
Manufacturing	Presenting data necessary for the planning of the deliveries of raw material. Recording and accumulating deliveries for each supplier.
Stockholding	Reporting stock depletions and deliveries for the domestic market.
Invoicing	Only invoices for domestic customers are produced by the computer system.
Sales-statistics	This is a simple system with a number of fixed and regular reports on domestic sales with the data organized with reference to customers, geographical area and productsize.

	Purchasing	Manufacturing	Stock-holding	Invoicing	Sales-statistics
Integration Complete Info reference	— complete external	— complete external	— partial internal	— partial external	— partial external
Variability Mode of present Value reference	fixed tabular forecasted actual	fixed tabular forecasted actual	fixed tabular actual	fixed tabular actual	fixed tabular actual
Operations Program origin	update aggregate own	update aggregate own	update aggregate own	update aggregate own	update aggregate own
Frequency of collecting	week a few times a year	week a few times a year	week	week	month
Frequency of reporting	week	week a few times a year	month	week	month
Period reference	a year	week, a year	month	present	month calendar-year
Life-time	fixed	fixed	fixed	fixed	fixed

Figure A1. Characteristics of Computerized Information Systems in Big Mill Division.

A2. CONSOLIDATED MILL DIVISION

1. General Data

Consolidated Mill, which is a division in a company group, produces and sells a foodstuff in a number of qualities and package-sizes (the same foodstuff as Big Mill Division). It is the only producer and major seller (only for direct consumption, major for industrial uses) of the product in Sweden. The whole of production is sold on the domestic market.

The company was formed by merging several companies. Today the company group has one major product, but also other products that are related, in terms of being required as production resources or being derived from the product. These other products belong, however, to other divisions in the company group.

Consolidated Mill accounts for the largest share of the sales in the company group. In 1976 turnover in Consolidated Mill was roughly 850 mill Sw Cr, and the number of employees around 2400.

The product is a mature one, a basic foodstuff, which is very old. The market is well-known and stable. Consumption of the foodstuff varies very slightly between years. The company and the market are both heavily regulated.

The division has used computers since the middle of the 1960s. It is the major computer user, in both absolute terms and also relative to its size, in the company group. The division has a unit for designing and administering computer systems, which also serves other divisions in the group. The users have been very active in the design of some computer systems. Several computer systems have been developed gradually.

The computerized information systems in Consolidated Mill are purchasing, manufacturing and stock-holding. They are only used by Consolidated Mill. All computer systems are batch processing systems.

2. Technology

Product	A limited line of products. They are all standard products, in different package-sizes.
Work-flow	The work flow can be divided into two: process production followed by large batch production. The work flow involved in process production consists of a fixed sequence of five steps and in large batch production, comprises only a few steps.
Material flow	Production is based on a sales plan and involves a combination of process production and large batch production; in between the product is put in storage. The material flow is expanding as one raw material is used to derive a number of products.
Techniques	Production is heavily mechanized and automated particularly in process production.

3. Environment

Customers	These are retailers, wholesalers as well as industrial users. There is a large number of customers. The customers are well-known.
Competitors	These are very few. No one within Sweden manufactures exactly the same foodstuff, though some industrial users sometimes import their own foodstuff, which may amount to 10% of the output of Consolidated Mill.
Suppliers	Consolidated Mill is the only user of the raw material. The raw material is bought from a large number of fairly small suppliers (more and smaller suppliers than in the case of Big Mill). The relations between the company and the suppliers are based on a continuous supply of the raw material. The supply of raw material decreased during the 1960s and has increased somewhat during the 1970s due to political decisions.

Regulations

There are regulations both which apply to the supply of raw material and the prices of the foodstuff. The regulations cover agreements for a number of years as well as yearly agreements. Their purpose is to adapt the industry to conditions within the European Community. The level of production of the foodstuff, and hence the degree of self-support, has varied due to regulations, which are influenced by political decisions.

4. Computerized information Systems

Purchasing

Purchasing concerns contracting and paying suppliers. Determining and recording the supply of raw material from each supplier, inspecting with regard to possible deviations between actual and contracted quantities. As the total yearly supply of raw material is restricted (according to agreements) it is necessary to distribute it among suppliers according to rules that take account of permitted supply, and the number and sizes of suppliers. These rules are embodied in a computer program, and number of variations are simulated and tested before a final distribution of the supply is agreed on between Consolidated Mill and representatives of the suppliers. Paying of suppliers. They receive preliminary payments a few times each year and a final settlement.

Manufacturing

Scheduling the deliveries from suppliers of raw material in order to keep the process production phase smoothly working. Scheduling and planning are seldom done. The deliveries of raw material are recorded and accumulated for each supplier.

Stock-holding

Stock transactions are recorded and stock-levels compared with plan. Planning invoices determining stock-levels and the amounts of different products or package sizes to be produced (in large batch production). This is done for a whole year based on a sales estimate. A plan is arrived at after testing by computer a number of alternatives. The procedure is repeated a few times each year.

	Purchasing	Manufacturing	Stock-holding
Integration Complete Info reference	— complete external	— complete external	— complete internal
Variability Value reference Mode of present	fixed forecasted actual tabular	fixed forecasted actual tabular	fixed forecasted actual tabular
Operations Program origin	update aggregate infer own	update aggregate own	update aggregate infer own
Frequency of collecting	day, week, a few times a year	week, a few times a year	week, a few times a year
Frequency of reporting	day, 2 day, week, a few times a year	week, a few times a year	week, a few times a year
Period reference	a year	week, year	week, year
Life-time	fixed	fixed	fixed

Figure A2. Characteristics of Computerized Information Systems in Consolidated Mill Division

A3. CONTAINER DIVISION

1. General Data

Container Division manufactures and sells containers of several sizes. It is the biggest division in a company group having a number of divisions making related products. Container Division accounts for roughly 80% of group sales (value).

The market of Container has grown rapidly and continues to expand. Around 90% of the production is sold outside Sweden.

The company group has central computer facilities and central resources for designing and administering computer system. These facilities and resources are utilized by all divisions, including Container. The computerized information systems in Container Division consist of manufacturing, stock-holding and order-entry. They are only used by Container, and they are all batch processing systems.

2. Technology

Product	A limited line of products, each with a large number of variations, including customized ones.
Work flow	Production consists of three steps, all products passing through the steps in the same order. (Fixed, three steps, sequential interdependence.)
Material flow	Production is in large batches and made to customer orders. The material flow is expanding, as a few raw materials results in several products. Throughput-time is short, 1-2 days.
Techniques	Production is heavily automated and mechanized. The equipment used involves considerable investment. Some of it is run continuously.

3. Environment

Customers	Potential customers belong to a limited number of industries. Once a firm has become a customer, Container Division can usually count on exclusive deliveries for a number of years.
Competitors	There are only a few competitors making similar products.
Suppliers	Raw materials are bought from a number of suppliers depending on the price/transportation relationship.

4. Computerized Information Systems

Manufacturing	A detailed estimate of future customer orders based on historical data of container-consumptions of customers. Expected quantities and times of future deliveries are computed. The estimates are used as a basis for planning ahead (external historical data used as a basis for internal future information).
Stock-holding	Recording and reporting stock transactions and stock-levels, particularly with regard to raw materials. Purchase orders are processed.
Order-entry	Recording and confirming customer orders daily. A report is produced weekly on the utilization (10 weeks ahead) of production equipment based on orders on hand.

	Manufacturing	Stock-holding	Order-entry
Integration Complete Info reference	— complete external, internal	— complete internal (external)	— complete external
Variability Mode of present Value reference	fixed tabular actual, forecasted	fixed tabular actual	fixed tabular actual
Operations	update aggregate infer	update aggregate	update aggregate
Program origin	own	own	own
Frequency of collecting	day, week, a few times a year	day	day
Frequency of reporting	week, 2 weeks	day, week	day, week
Period reference	3 months ahead	present	present, 10 weeks ahead
Life-time	fixed	fixed	fixed

Figure A3. Characteristics of Computerized Information Systems in Container Division

A4. DECOR DIVISION

1. General Data

Decor Division manufactures and sells a line of products for interior decoration, in private as well as public domains. The division is a major one in a Swedish company group, accounting for nearly 25% of group sales. In 1976 the division sales amounted to roughly 180 mill Sw Cr (slightly more than half are foreign sales) and the number of employees was around 800.

The products manufactured have been on the market for around 50 years. During this time the line has undergone changes due to new - and better - materials. This has meant that the line could be extended, more variations are possible now than previously. There have however been no changes in the principles of technology.

The products are mature ones but there are application areas that have not yet been tapped. The original market has tendencies to stagnate, and the outlook is not considered as very bright for the next few years. The division is however sensitive to changes and business cycles in customer industries.

The company group has used computers since the beginning of the 1960s. Decor Division is the major computer user, and several computer systems have been designed on the initiative of Decor, other divisions joining later. The group has a central computer, with facilities for on-line-use, and a central staff-department for designing and administering computer systems.

The computerized information systems in Decor are stock-holding, Order-entry, order-statistics, invoicing and sales-statistics. They are used by most divisions in the company. Order-entry and invoicing are direct processing systems, the rest are batch processing ones.

2. Technology

Product	A line of products for internal decoration. They are offered in several sizes, finishings and designs. New variations are introduced each year, while others are discontinued. The product appeared about 50 years ago, but had its break-through much later, when new materials made it possible to offer a much wider line.
Work flow	Production consists of three steps, all products passing through the steps in the same order. Interdependence is hence sequential.
Material flow	Production is in large batches. Some products are manufactured for stock, others on the basis of customer orders. The material flow is expanding as a limited number of raw materials results in a wide range of products (the relation being 1:75). Through-put time is one week for each step.
Techniques	One step is mainly manual work, the rest are heavily automated. Production requires heavy and expensive equipment. Some types of equipment are available in different sizes.

3. Environment

Customers	There are a large number of customers, both whole-salers and endusers. There have been changes, particularly declines, in several previous markets and consumer-industries. Decor Division has therefore had to find new markets and new uses for the line of products.
Competitors	There are both competitors making equivalent products and competitors manufacturing substitute products for identical application areas. There are several competitors. There are some manufacturers with a product-line similar to the Decor-line in most countries.
Suppliers	There are different types of suppliers for different raw materials. Some raw materials are supplied by other divisions in the company group.

4. Computerized Information System

Stock-holding	Recording and reporting of transactions of levels of stock, raw materials as well as finished products. Determining replenishments of inventory, reservations for customer orders. The Wilson-model is used to determine re-order-point and production quantity for finished products. Query-facilities.
Order-entry	Recording and confirming orders. Delivery notes are produced. The computer equipment is decentralized, i e each division has a number of terminals on-line to the central computer.
Order-statistics	This is a new system, replacing a previous system. The previous one was only used by Decor Division. Receipt of orders and orders on hand are recorded and accumulated. The user requests reports, specifying the grouping and partitioning of data. Several possible ways of partitioning data are available. A report-generator is used. Data are extracted from order-entry, and prices and product-classifications etc added.
Invoicing	Producing invoices. The same kind of equipment is used as in order-entry.
Sales-statistics	The user requests reports, specifying grouping and partitioning of data, and also partly the degree of detail in reports. Several possible ways of partitioning data. A report-generator is used. Data from invoicing are used, after adding prices, product-classifications etc.

	Stock-holding	Order-entry	Order-statistics	Invoicing	Sales-statistics
Integration Complete Info reference	— complete internal	with invoicing complete external	— complete external	with order-entry complete external	— complete external
Variability Mode of present Value reference	fixed tabular actual, forecasted	fixed tabular actual	variable tabular actual	fixed tabular actual	variable tabular actual
Operations	update aggregate infer	update aggregate	update aggregate transpose	update aggregate	update aggregate
Program origin	own	own	own	own	own
Frequency of collecting	day, month	continuous	week, month (as requested)	continuous	month
Frequency of reporting	day, week, month, 4 month, year	continuous, day	week, month	continuous, day	month
Period reference	day, week, month, 4 month, year	present	week or month (comparisons as requested)	present	month (calendar-year for comparisons)
Life-time	fixed	fixed	requested	fixed	requested

Figure A4. Characteristics of Computerized Information Systems in Decor Division

A5. LIGHT ENGINEERING DIVISION

1. General Data

Light Engineering Division is the biggest division in a Swedish company group, and accounts for roughly 40% of group sales. In 1976 sales amounted to ca 160 mill Sw Cr and the number of employees was approximately 800 in Light Engineering.

The division manufactures light engineering products. It is a fairly new product range, with a number of variations. It is an automatic safety device, which competes with similar non-automatic ones. The market is rapidly increasing and, 80% of production is exported.

Light Engineering has a small unit for developing and administering computer systems, but the division also needs to use the central resources of the company group. Light Engineering has no computer of its own but uses the same computer that is used by other divisions in the company group. The division was the first computer user in the company group and has used computers since ca 1970.

The computerized information systems consist of manufacturing, stock-holding and sales-statistics. They are all batch processing systems.

2. Technology

Product	A single standardized product with a small number of variations. Each unit is assembled from a number of components; some components are made by Light Engineering, others are made by sub-contractors according to specifications by Light Engineering, still others are standard-parts. The variations are limited to a few components. The product is slightly more than 10 years old.
Work flow	Production is divided into two steps, which are performed in a fixed sequence. In the first step components that are not sub-contracted or bought are manufactured. The second step involves assembling the different components. (Two steps, fixed sequence, sequential interdependence.)
Material flow	Production is in large batches, and the company attempts to combine batches for different customers in order to economize production, reduce set-up costs etc. Production is for stock. The material flow is contracting as a product is assembled from a number of components. Through-put time is a few weeks.
Techniques	Production is highly mechanized and automated, using standard machinery, to obtain flexibility, and specialized machinery, in order to reduce production costs and simplify production.

3. Environment

Customers	These are manufacturers of certain types of large-scale equipment, where the device manufactured by Light Engineering is used as a safety-component. (In similar types of equipment but of a smaller scale the device is not used.) The number of customers is limited. The customers are well-known and well-established in their markets. They buy in large quantities, hence producing few orders and few invoices.
Competitors	Competition is limited. There are few competitors and few competing products. The product manufactured by Light Engineering is an automatic one, but the majority of the competing ones are non-automatic.
Suppliers	Suppliers consist of those supplying raw materials for components of own manufacturing, sub-contractors for certain components, and manufacturers of standard parts.

4. Computerized information Systems

Manufacturing	Parts explosion based on a prognosis of sales during a year. The result is used as a basis for purchasing.
Stock-holding	Reporting and recording stock transactions and levels for raw materials, components and finished products. It is possible to reserve materials or components for future production. There is no use of the Wilson-model.
Sales-statistics	Simple statistics based on data from invoices. Quantitative sales, deviation from budget. Sales figures broken down periodically in terms of customers and geographical areas. Accumulated sales.

The production and stock-holding systems are used only Light Engineering and not by any other division in the company group. The system for sales statistics is quite recent, it has been developed centrally, and the intention is that all divisions in the group will use it.

	Manufacturing	Stock-holding	Sales-statistics
Integration Complete Info reference	— complete external, internal	— complete internal	— complete external
Variability Mode of present Value reference	fixed tabular forecasted, actual	fixed tabular actual	fixed tabular actual
Operations Program origin	update aggregate infer own	update aggregate own	update aggregate own
Frequency of collecting	2 months	1 week	1 month
Frequency of reporting	2 months	1 week	1 month
Period reference Life-time	1 year ahead fixed	1 week fixed	1 month past fixed

Figure A5. Characteristics of Computerized Information Systems in Light Engineering Division

A6. MACHINE DIVISION

1. General Data

Machine Division develops, manufactures and sells engineering products. The products have a limited area of application. The company group has a number of divisions making related products. Machine Division accounts for roughly 10% of group sales.

The market has increased steadily and it is likely that sales will continue to increase. The major part of production is exported. Some products are stagnating, while others continue to increase substantially.

The company group has central computer facilities and central resources for designing and administering computer systems. These resources are utilized by Machine Division, and a number of designers and programmers have particular responsibility for the computer systems used by Machine Division.

The computerized information systems in Machine consist of purchasing, stock-holding and order-entry. They are all batch processing systems, and stock-holding and order-entry are integrated.

2. Technology

Product	A limited line of products, each with a number of variations. The products are fairly young, and new variations are still being introduced. In addition to finished products Machine Division supplies spare parts.
Work flow	Production is heavily dependent on sub-contractors. The number and order of steps varies among products. The number of steps is fixed for each type of product.
Material flow	Production is in small batches. Production is based on sales forecasts, as the turn-around-time is extremely long, and customer-orders do not arrive until the end of production. The material flow is contracting, as the products are assembled from a number of components.
Techniques	The equipment and tools necessary for assembling the products are limited.

3. Environment

Customers	The customers belong to a limited, well-defined and well-known industry.
Competitors	The number of competitors making similar products are limited.
Suppliers	The most important are sub-contractors within engineering industry. The components are usually ordered in small batches. The sub-contractors must be able to change production quickly.

4. Computerized information Systems

Purchasing	Purchasing-recommendations, i.e. parts that need to be replenished, are produced once a week. The recommendations are reviewed and the purchases decided entered daily into the computer system resulting in purchase-orders and the like.
Stock-holding	Recording and reporting stock transactions and levels. The Wilson-model is used in determining order-point and order-quantity. Both the parent company and its foreign affiliates are included. The affiliates reporting weekly.
Order-entry	Recording customer orders, producing orders, producing order confirmations etc.

	Purchasing	Stock-holding	Order-entry
Integration Complete Info reference	— complete external	with order-entry complete internal	with stock-holding complete external
Variability Mode of present Value reference	fixed tabular forecasted	fixed tabular actual	fixed tabular actual
Operations	update aggregate infer	update aggregate infer	update aggregate
Program origin	own	own	own
Frequency of collecting	day	day, week	day
Frequency of reporting	day, week, 2 weeks, 3 weeks	day, week, month	day
Period reference	present	present	present
Life-time	fixed	fixed	fixed

Figure A6. Characteristics of Computerized Information Systems in Machine Division

A7. PARTS MANUFACTURING DIVISION

1. General Data

Parts Manufacturing Division accounts for approximately 14% of sales in a Swedish company group. In 1976 division sales amounted to 145 mill Sw Cr and the division had around 900 employees.

The division manufactures and sells moulded products used as parts or components in products manufactured and sold by other companies. To a large extent production is advanced commission work.

Domestic sales dominate, and only a minor proportion of the product is exported. The market is a stagnating one.

The company group has a powerful computer and a central staff-department for designing and managing computerized information systems. The Parts Manufacturing Division has no computer resources of its own and no unit for computer system design of its own. When a new computer system is being designed, one or two employees in the division participates. Computers have been used since the beginning of the 1960s.

The computerized information systems consist of order-entry, stock-holding, manufacturing and sales-statistics.

2. Technology

Products	A line of products. The majority of products are customized, made with particular regard to customer needs. A small proportion is standard-products, and some products are pure specialized products. The age of the products varies, the average age being 3 or 4 years. All products are made using the same kinds of raw materials, in addition some products contain parts of a different material.
Work flow	Production is divided into a number of steps. The sequence of steps is fixed, with an additional step for certain types of products using additional material. Interdependence is sequential.
Material flow	Production is in large batches. Standard products are made for stock while, other products are based on orders from customers. The material flow is expanding, as a limited number of raw-materials are used in producing a wide range of products.
Techniques	Mechanization of production varies. Some steps in the work flow are half-automated, others are still mainly manual. To manufacture the products special tools are required. By changing the tools in the equipment used, different products can be made.

3. Environment

Customers	There is a large number of customers, making up a comparatively fixed stock. The customers are similar in several respects, and have similar business cycles.
Competitors	There are several competitors. Competition is tough, particularly with regard to standard products. There are several manufacturers of similar products in Sweden and in the export-markets.
Suppliers	Several other divisions use the same raw materials. There are no particular difficulties in acquiring raw materials for the company group.

4. Computerized Information Systems

Manufacturing	Parts explosion of products, and cost estimates. The system is used as a basis for production scheduling, estimating semi-manufacturers and raw materials in advance.
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Stock-holding	Reporting and recording of stock levels of materials and particularly of finished products. Reports on products produced for storage; query-and-answer-facilities.
Order-entry	Recording of customer orders, producing order confirmations, delivery documents etc. Computerized order-entry does not cover special customer orders.
Sales-statistics	Monthly reports of sales arranged with reference to product types or geographical markets. Comparisons with previous sales, 2 or 3 years back, are possible. Some reports are standardized, others are produced by using a report generator.

Order-entry and stock-holding are integrated. The integrated computer system is an on-line real-time system. The computer systems for manufacturing and sales-statistics are, however, batch processing systems. The computerized information systems are used by roughly a third of the divisions in the group.

	Manufacturing	Stock-holding	Order-entry	Sales-statistics
Integration Complete Info reference	— complete internal	with order-entry complete internal	with stock-holding partial external	— complete external
Variability Mode of present Value reference	fixed tabular actual forecasted	fixed tabular actual	fixed tabular actual	variable tabular actual
Operations Program origin	update aggregate infer own	update aggregate own	update aggregate own	update aggregate transpose own
Frequency of collecting	month	continuous	continuous	month
Frequency of reporting	month, week	continuous, week	continuous	month
Period reference	month, week	current, week	current	1 month past (and further back)
Life-time	fixed	fixed	fixed	may be requested

Figure A7. Characteristics of Computerized Information Systems in Parts Manufacturing Division

A8. STANDARD DIVISION

1. General Data

Standard Division accounts for roughly 15% of sales turnover in a Swedish company group. In 1976 division sales amounted to 155 mill Sw Cr and the division had around 600 employees.

The division manufactures and sells a line of standard products. The division has for some time had difficulties in selling some products, which finally have forced it to discontinue manufacturing these products. Instead the division has taken up the production of similar products for different uses and sold to other types of customers. The technology used is the same in both cases.

Instead of increasing as expected, the total market for standard products has decreased. Further there was over-capacity in the market. The uncertainty in the market has increased. Standard division's sales decreased sharply forcing the division to discontinue manufacturing the standard products. A new line is being introduced, directed toward special applications areas.

Standard Division utilizes the powerful computer in the company group. The division has no resources for computer system design of its own, instead it uses the central staff-department for designing and administering computer system. Some employees from the division participate when a new computerized information system is developed. Computers have been used since the beginning of the 1960s.

The computerized information systems in Standard consist of manufacturing, stock-holding and sales-statistics. The computer systems are used only by Standard division in the group. They are all batch processing systems.

2. Technology

Product	A line of products, from a number of standardized products the division is changing to a different line of standardized but technologically similar products directed towards particular fields of applications. The line of products has increased. The present products are fairly young, new ones introduced every year.
Work flow	Production is divided into four steps, which are performed in a fixed sequence. Interdependence is sequential.
Material flow	Production is in medium to large batches. All products are manufactured towards inventory. The material flow is expanding as a few raw-materials can be used to manufacture several products by changing certain tools.
Techniques	Production is mechanized but there is also a large element of manual tasks.

3. Environment

Customers	The composition of customers for the standard products has changed considerably during the last years. The new line of products is directed toward new types of customers who are more specialized. The change is from users to producers of equipment containing products produced by Standard.
Competitors	The old line of products was made by most manufacturers in the industry. The market is, however, dominated by large international manufacturers, and standard is small in comparison. Competition was heavy and price-oriented. Only manufacturers introducing technologically advanced products were profitable. There are, fewer competing manufacturers, for the new line hence the competitive situation is expected to improve.
Suppliers	There are no particular difficulties in acquiring raw-materials, certain raw-materials are in surplus, some raw-materials are also used by other divisions in the company group.

4. Computerized Information Systems

Manufacturing	Production statistics concerning consumption of raw-materials, production (forecasted and actual)
Stock-holding	Recording and reporting stock levels and stock transactions. Monthly basic scheduling data are reported, concerning stock movements per month during a year back. It is used as a basis for manual scheduling of production and stock-holding for the next month.
Sales-statistics	Monthly reports of sales. A package of reports is produced monthly, a user orders required reports from this package. The reports are arranged with reference to products or markets.

	Manufacturing	Stock-holding	Sales-statistics
Integration Complete Info reference	— complete internal	— complete internal	— complete external
Variability Mode of present Value reference	fixed tabular actual, forecasted	fixed tabular actual, forecasted	package tabular actual
Operations Program origin	update aggregate own	update aggregate own	update aggregate own
Frequency of collecting	week	2 days	month
Frequency of reporting	week	2 days, month	month
Period reference	week past	2 days, 1 month past and ahead, year back	past month
Life-time	fixed	fixed	fixed

Figure A8. Characteristics of Computerized Information Systems in Standard Division

A9. SUCTION DIVISION

1. General Data

Suction Division belongs to a Swedish company group, and accounts for roughly 25% of group sales. In 1976 sales amounted to ca 90 mill Sw Cr and the number of employees was approximately 400 in Suction Division.

The division manufactures heavy engineering equipment, which is used in several types of industry. Suction makes and sells equipment; in addition Suction also sells certain varieties of the equipment made by other manufacturers. The products are technically advanced. In addition to making and selling equipment, Suction division makes and sells spare parts.

The market is stagnating, and is heavily dependent on market developments in customer-industries. During the last few years some markets have completely disappeared due to structural changes in the industries concerned. The export share varies among industries.

Suction has a small unit for developing and administering computer systems, but also needs to use the central resources in the group. Suction uses a computer which is used by other divisions in the company group, as Suction has no resources of its own. The Division is a fairly new user of computers, and some of its attempts made in the early 1970s failed.

The computerized information systems consist of purchasing and stock-holding. They are both batch processing systems.

2. Technology

Product	A line of similar products, heavy equipment, for different industries. Some varieties have a customized design, others are based on standardized parts plus some parts that may vary according to the needs of the customer. Spare parts. It is a very old product.
Work flow	Production consists of a number of steps, which are performed in a fixed sequence. Interdependence is sequential.
Material flow	Production is in units or small batches. Production is for customer orders (for finished products). The material flow is contracting as a product is assembled from a number of components. Scheduling of the material flow is based on cycles, some products appearing in each cycle, others with bigger gaps. Through-put time is 8 weeks. (Unit or small batch, order, contracting).
Techniques	Production is mechanized, but there is only limited use of automatic machinery. The strength of the Division is its ability to work with complex material.

3. Environment

Customers	Customers belong to a range of industries. The equipment manufactured by Suction Division is mostly used as part of the production process of the customers.
Competitors	The number of competitors are few, although there is usually a manufacturer of similar heavy equipment in most countries. It is hard to enter a market in a new country, usually because of heavy price-competition.
Suppliers	Depending on the type of material or components, suppliers may be located in different areas. There is basically a fixed stock of suppliers although there may be alternative suppliers. For certain common parts few changes among suppliers.

4. Computerized Information Systems

Purchasing Information on materials and components that need to be ordered. Information on purchases distributed on materials and suppliers.

Stock-holding Reporting and recording stock transactions and stock levels. Parts explosion of orders from customers. Only some types of components are included, others are based on prognosis, still others on physical inventory.

The systems are very simple, and the plan is to extend them in different directions, primarily towards production by designing capacity files etc.

	Purchasing	Stock-holding
Integration Complete Information reference	— partial external	— partial internal
Variability Mode of present Value reference	fixed tabular actual, forecasted	fixed tabular actual
Operations	update aggregate transpose	update aggregate
Program origin	own	own
Frequency of collecting	week	week
Frequency of reporting	week, year	week
Period reference	week, year	week
Life-time	fixed	fixed

Figure A9. Characteristics of Computerized Information Systems in Suction Division

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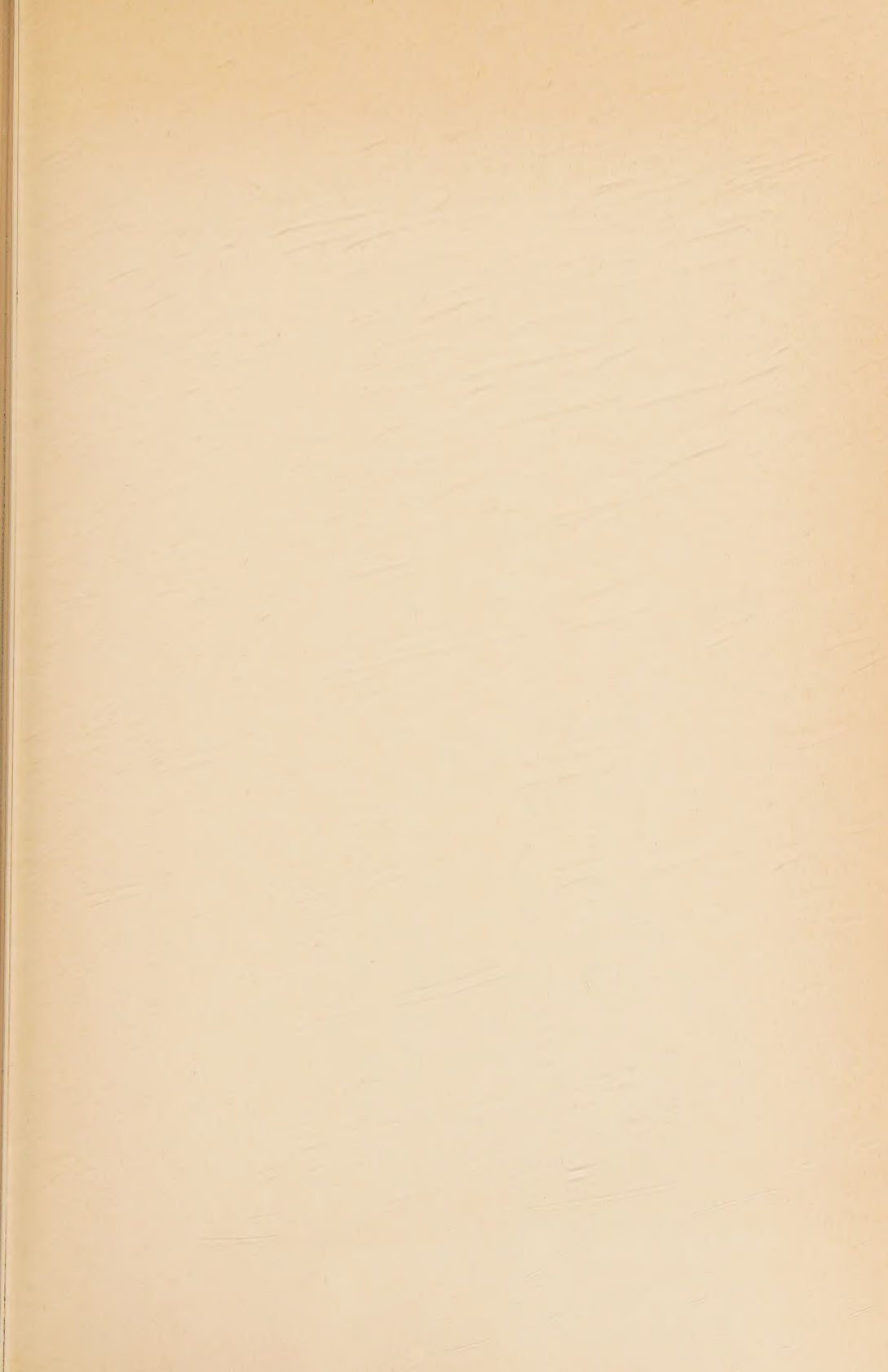
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